UNIVERSITY OF DELHI

CNC-II/093/1(28)/2023-24/262

Dated: 26.10.2023

N O T I F I C A T I O N

Sub: Amendment to Ordinance V

[E.C Resolution No. 14-1/-(14-1-6/-) dated 09.06.2023 and 27-1-1/ dated 25.08.2023]

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

Syllabi of Semester-IV, V and VI of the following departments under Faculty of Science based on Under Graduate Curriculum Framework -2022 implemented from the Academic Year 2022-23 :

(i) Anthropology

(ii) Biological Science (Sri Venkateswara College)

(iii) Biomedical Science (ACBR)

(iv) Environmental Studies

(v) Polymer Science

DEPARTMENT OF ANTHROPOLOGY
BSc. (Hons.) Anthropology
Semester-4

DISCIPLINE SPECIFIC CORE COURSE -10 (DSC-10)
Human Genetics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Human Genetics	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objectives

1. To introduce the students the basic principles of human genetics.
2. To familiarize the students with the methods/technologies used in genetic research.
3. Aims to provide knowledge about the pattern of inheritance of genetic disorders, genetic abnormalities and the importance of genetic testing and counseling.

Learning Outcomes
Student will be able to:
1. describe the structure and function of DNA; concept of gene, transcription and translation.
2. grasps the inheritance pattern of human traits/diseases and types of chromosomal abnormalities and their implications.
3. handle the methods and techniques used in human genetics.
4. comprehend the importance of genetic counselling.

Unit 1: Human Genome, Chromosomes and Abnormalities (09 Hours)
History of Human genetics; Concept of gene; Chromosomal structure and abnormalities, Cytogenetics, and Human Genome Project

Unit 2: DNA Structure and Function (09 Hours)
DNA Structure and Function, DNA Replication, repair and recombination, gene expression, coding and non-coding regions. Expression of genetic information: from Transcription to Translation - the relationship between genes and protein.

Unit 3: Patterns of Inheritance (09 Hours)

Mendelian inheritance (Autosomal and X linked); Co-dominance; Sex-linked inheritance; Multiple allelism; Dosage compensation, Single factor and multifactorial inheritance and Non-Mendelian inheritance

Unit 4: Methods in Human Genetics (09 Hours)
Pedigree analysis, methods of assessing chromosomal abnormalities (Banding techniques; Karyotyping; FISH); Sib-pair and Twin studies; Genotyping and Sequencing methods

Unit 5: Genetic Diagnosis and Counselling (09 Hours)
Prenatal diagnosis; Newborn screening; Genetic counseling

Practical (30 hours)
Project report based on data collection related to one mendelian disorder on the basis of brief field visits, in nearby areas.

References

1. Brown TA. (2007). *Genomes*. Garland Science.
2. Cummings MR (2011). *Human Heredity: Principles and Issues*. Brooks/Cole, Cengage Learning
3. Klug WS (2012). *Concepts of Genetics*. Pearson.
4. Lewis R. (2009). *Human Genetics: Concepts and Application*. The McGraw−Hill Companies, Inc.
5. Vogel F. and Motulsky A.G. (1996). *Human Genetics: Problems and Approaches*. Springer, 3rd revised edition.

Teaching Learning Process
The process of learning will involve acquisition of domain knowledge and understanding of skills required for conducting human genetic research. Process will involve lectures and presentations and report submission.

Assessment Methods
Examination schemes and mode shall be as prescribed by the Examination Branch, University of Delhi from time to time.

Keywords
Human genetics, DNA, chromosomal abnormalities, anthropology, sequencing

DISCIPLINE SPECIFIC CORE COURSE -11 (DSC-11)
Kinship and Polity

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Kinship and Polity	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course objective

This course seeks to impart basic anthropological knowledge on themes in the studies of kinship, Family and Marriage, and various political systems.

Learning Outcomes

The students will be able to:

- demonstrate understanding of key anthropological debates and approaches to kinship studies.
- differentiate between different kinds of marriage rules and family types.
- elucidate analysis of power in different forms of political systems.

Syllabus:

Unit 1 (10 Hours)

Approaches to the study of Kinship; Descent, Alliance and cultural Theories; Kinship Usages, Terminologies; Redefining Kinship

Unit 2 (11 Hours)

Marriage and Family : Problems of definition; Approaches to the study of Family; Domestic Group and Household

Unit 3 (12 Hours)

Descent and Political Systems; Approaches to the study of Political Anthropology; Power, Authority and Legitimacy; State and stateless societies

Unit 4 (12 Hours)

Nation, Nation State and Citizenship; Customary Laws; Social Movements

Practical (30 hours)

1. Collect and analyse genealogies of a person and find out the inter-generational changes in terms of age at marriage, education qualification, household, occupation and migration pattern.

2. Conduct an in-depth interview to find out the changing marriage practices and family types.

3. Case study of any current political instance/event in social media to understand how people imagine the state, and are involved in power relations

References

1. Fortes, Meyer, and Evans-Pritchard. (1950) (4th edition). *African Political Systems*. London: Oxford University Press
2. Harris, C. C. (1990). *Kinship. Concepts in social thought*. Minneapolis: University of Minnesota Press.
3. Karve, Irawati. (1968). *Kinship organization in India*. London: Asia Publ. House.
4. Lévi-Strauss, Claude. (1969). *The elementary structures of kinship*. Boston: Beacon Press
5. Shah, A.M (1998). *The Family in India: Critical Essays*. New Delhi : Orient Longman
6. Spencer, Jonathan (2007). *Anthropology, Politics, and the State: Democracy and Violence in South Asia.* University of Edinburgh: Cambridge University Press.
7. Stone, Linda and Diane E King. (2019). *Kinship and Gender: An Introduction* (6th edition). New York: Routledge.
8. Uberoi, Patricia (1994) *Family, Kinship and Marriage in India.* New Delhi: Oxford University Press.
9. Vincent, Joan (ed.) (2002). *The anthropology of Politics: A reader in ethnography, theory and critique*. Blackwell publisher

Teaching Learning Process

Lectures and Discussions, Seminars and Presentations, Practical Classes

Assessment Methods

Examination schemes and mode shall be as prescribed by the Examination Branch, University of Delhi from time to time.

Keywords:

Kinship, Marriage, Family, Politics, Customary Law

DISCIPLINE SPECIFIC CORE COURSE -12 (DSC-12)
Archaeological Fieldwork (4-7 days)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Archaeological Fieldwork	04	02	Nil	02	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course objectives:
To expose students to different prehistoric sites of India.

Learning Outcomes: The students will be able to:
1. demonstrate the understanding of the lithic industry.
2. identify prehistoric tools in situ.
3. describe the stratigraphic context of the tools.

Syllabus:

Unit 1 Methods in Archaeological Anthropology: (07 Hours)
Distinction between exploration, expedition, field Survey and ethnoarchaeology

Unit 2: Geological Background of the Region (07 Hours)
Geomorphology, Geochronology, Topography, Flora and Fauna, Sedimentology

Unit 3: Understanding Culture (08 Hours)
Artifacts and tools, Tool Types, and technology of different cultural periods of prehistoric times

Unit 4: Interpretation of Culture (08 Hours)
Analysis of material, Drawing, Dating of artifacts and logic of inference

Practical (60 Hours)

1. Analysis of Prehistoric Tools: Identification, Interpretation and Drawings of the tool types with special reference to the technology and chronology:
Core Tool Types
Flake Tool Types
Blade Tool Types

2. The students are required to conduct an archaeological fieldwork in a selected region of India for a period nearly 7 days and submit a field report.

References

1. Bhattacharya, D.K (2006). *An outline of Indian Prehistory*. Palaka Prakashan Delhi.

2. Bhattacharya, D.K. (1979). *Old Stone Age Tools: A Manual of Laboratory Techniques of Analysis.* Calcutta: K. P. Bagchi and Company

3. Inizan, M.L.; M. R. Ballinger; H. Roche and J. Tixier. (1999). *Technology and terminology of Knapped Stone.* Nanterre: CREP.

4. Oakley, K.P. (1972). *Man the Tool Maker*. London. Trustees of the British Museum of Natural History.

5. Renfrew Colin and Bahn Paul. (2012). *Archaeology: Theories, Methods and Practice*. New York: Thames & Hudson, 6th Edition.

6. Sankalia, H.D. (1982). *Stone Age Tools: Their Techniques, Names and Probable Functions*. Poona: Deccan College.

7. Whittaker, J.C. (2009). *Flintknapping: Making and Understanding Stone Tools.* Austin: University of Texas Press.

Teaching Learning Process

Classroom Presentations using digital methods
Practical classes
Seminars and presentations by students
Field visit to an archaeologically important site

Assessment Methods

Examination schemes and mode shall be as prescribed by the Examination Branch, University of Delhi from time to time.

Keywords

Prehistoric, Archaeological, stone tools, material culture and evolution

POOL OF DISCIPLINE SPECIFIC ELECTIVES

DISCIPLINE SPECIFIC ELECTIVE COURSE -5 (DSE-5)
Physiological Anthropology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Physiological Anthropology	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objectives

1. To familiarise the student with the idea of homeostasis, physical performance, physiological adaptation and factors influencing adaptation.

2. To make them understand the relationship between physique and human body composition

Learning Outcomes

The students will be able to:

1. demonstrate understanding of the fundamentals of physiological anthropology.
2. to identify the physiological changes during performance and factors influencing adaptation with respect to environmental adaptation.
3. relate physique and human body composition on one hand and the importance of nutrition on the other.

Unit 1 (10 Hours)

Fundamentals of work physiology- homeostasis; metabolism and energy and systems; exercise, respiratory system and haemodynamics (blood pressure, pulse, rate, heart rate, and heamatocrit).

Unit 2 (11 Hours)

Acute physiological adjustments during transition from resting homeostasis to sub-maximal and maximal exercise and physiological adaptations

Unit 3 (12 Hours)

Cardio-vascular and respiratory endurance, physical working capacity and physical fitness; Reproductive health, regulation of metabolism, growth and energy balance

Unit 4 (12 Hours)

Physical performance and environmental stress; inter-relationship between physique, body composition and nutrition

Practical (30 Hours)

1. Measure the cardiovascular functions -
Blood pressure
Heart rate
Pulse rate

2. Measure the Respiratory functions (Static and Dynamic lung functions)

3. Physical activity assessment

References

1. C. Bouchard, S.N Blair,W.L Haskell (Editors) (2014). *Physical Activity and Health*. 2nd Edition. Human Kinetics.

2. William D. McArdle, Frank I. Katch, Victor L. Katch (2014). *Exercise Physiology Energy, Nutrition and Human Performance.* Lippincott Williams & Wilkins.

Teaching Learning Process
Classroom teachings
Seminars and presentations
Practical classes

Assessment Methods
Examination schemes and mode shall be as prescribed by the Examination Branch, University of Delhi from time to time.

Keywords:
Exercise physiology, cardio-respiratory endurance, physical working capacity, fitness, environmental stress

DISCIPLINE SPECIFIC ELECTIVE COURSE -6 (DSE-6)
Gender and Society

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Gender and Society	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objectives

This course will expose the students to a fundamental understanding of gender and the related phenomena in historical and contemporary context. Using anthropological lens, the students will explore, interpret, analyse and deal with gender concerns in everyday life.

Learning Outcomes

At the end of the course, the students will be able to:

1. elucidate the theories on the social construction of gender categories.
2. comprehend gender rights, gender justice, particularly in Indian context.
3. describe the contemporary gender issues in its various manifestations in India.

Unit 1 Anthropology of Gender (10 Hours)

Basic concepts, definitions, and terminologies. History and theoretical developments, approaches and orientations.

Unit 2. Gender, Sex and Sexualities (11 Hours)

Sex/Gender and sexuality. Gender identity and expressions, Embodiment and Bio-politics, Queer Anthropology

Unit 3. Gender in South Asia (12 Hours)

Gender narratives and performances, gender and development, Gender rights and gender justice, politics and activism, CEDAW

Unit 4. Intersectional Framework (12 Hours)

Gender, ethnicity, caste, disability and others

Practical (30 Hours)

The students shall prepare comprehensive project based on short fieldwork or from secondary sources on different dimensions of gender issues.

References

1. Aneja, Anu (2019) *Women's and Gender Studies in India: Crossings*. Routledge

2. Channa, Subhadra Mitra. (2013). *Gender in South Asia: Social Imagination and Constructed Realities*. Cambridge University Press.

3. de Beauvoir, Simone (2015). *The Second Sex*. Vintage Classics. Chicago.

4. Dube, Leela (Ed.), (2001). *Anthropological explorations in gender: Intersecting Fields*. New Delhi: Sage Publications.

5. Mascia-Lees E. Ffrances, Nancy Johnson Black (2017) *Gender and the Body*. Illinois. Waveland press.

6. Mehrotra, Nilika (2013). *Disability, Gender and State Policy: Exploring Margins*. Jaipur: Rawat Publications.

7. Ortner, Sherry B. (1996). *Making Gender: The Politics and Erotics of Culture*. Boston: Beacon

Teaching learning process

Lectures, Active participation of students in class debates and discussions, sharing of experiences and dialogues. Innovative fieldwork exercises and workshops, short documentaries on gender issues.

Assessment Methods

Examination schemes and mode shall be as prescribed by the Examination Branch, University of Delhi from time to time.

Keywords:

Gender and Sexuality, Feminism, Gender Identity, Gender Narratives, Gender Performances, Gender Rights and Gender Justice**.**

DISCIPLINE SPECIFIC ELECTIVE COURSE -7 (DSE-7)
Material Culture and Museology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Material Culture and Museology	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course objective

1. To expose the students the community relationship to their surrounding through study of material culture.
2. To make them aware of the role of museums in heritage cultural preservation

Learning Outcomes

The students will be able to :

1. demonstrate the understanding of the social history of the community through the study of museum objects.
2. to deconstruct the biases in the writings of colonial accounts through the study of material culture.

Syllabus:

UNIT 1: Material Culture and Consumption (10 Hours)
Bodily adornment and social/symbolic categories; Material culture and social life of things

UNIT 2: Museums and Museology (12 Hours)
The Origins of the Museum; Architecture and the 'Museum Effect'; The Curator and the Exhibition: Assimilating and exoticizing; Interpreting Museum Texts

UNIT 3: Museums and Colonialism (11 Hours)
Exhibiting Sacred Art; Museums and Gender; Digital Museums, Digital Museology; Decolonising the Museum

UNIT 4: Museology and Conservation (12 Hours)
Techniques of conservation, Community Museums.

Practical (30 Hours)

1. The students are required to understand the structure and function of material culture pertaining to different social institutions and activities through specific drawing and their analyses.
2. Use of technology (such as audio-visual and digital) to enrich the museum experiences.
3. Undertake visit to different types of museums and prepare a brief report.

References

1. Appadurai, Arjun. (1986). *The Social life of things*. New York: Cambridge University Press
2. Gell, Alfred. (1998). *Art and Agency: An anthropology theory*. Clarendon Press
3. Ingold, Tim. (2002). *Companion Encyclopedia of Anthropology*. London: Routledge
4. Miller, Daniel. (1997). *Material Cultures: Why some things matter*? London: Routledge.
5. Marwah, I.S. and V.K. Srivastava. (1987). Khel gate and social structure: a study of their relationship and a note on the place of material culture in anthropology. *Indian Anthropologist*, 17 (2): 63-99

Teaching Learning Process

The students will be encouraged to review relevant literature to understand museum artefacts. Museum visits will be organized and the systemic review of material objects will be carried out.

Assessment Methods
Examination schemes and mode shall be as prescribed by the Examination Branch, University of Delhi from time to time.

Keywords:
Museum, Museology, Tribal arts, Artefacts

DISCIPLINE SPECIFIC ELECTIVE COURSE -8 (DSE-8)
Nutritional Anthropology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Nutritional Anthropology	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objectives

To understand human diet and nutrition from an explicitly anthropological perspective; augment the basic knowledge of nutrition with special reference to its evolutionary perspective by developing deeper insights of biocultural perspective in the contemporary food habits and dietary practices.

Learning Outcomes

The students will be able to:

1. demonstrate understanding of the importance of nutrition in lifestyle diseases,
2. identify nutritional transition, and eco-cultural zones
3. describe the emerging trends in lifestyle diseases due to nutritional abnormalities.

Syllabus:

UNIT1 Introduction to Nutritional Anthropology (12 Hours)
Basic principles, aim and objectives of nutritional anthropology, Macro- and micro-nutrients and their importance in health, Trace elements and their importance in human nutrition.

UNIT 2 The Evolutionary Background (12 Hours)
Palaeolithic diet, Evolution of diet.

UNIT 3 Biocultural diversity of food and nutrition (12 Hours)
Eco-cultural zones, diet and nutrition, culture and Food Diversity, dietary and nutritional transition and lifestyle, Undernutrition and malnutrition and Nutritional disorders.

UNIT 4 Nutritional Requirements (09 Hours)
Recommended dietary

PRACTICALS (30 Hours)

1. Anthropometric assessment of nutritional status: Somatometery (Height, weight, BMI, Body fat percentage, Circumferences)
2. Development of Food Frequency Questionnaire (FFQ)
3. Haemoglobin and glucose estimation
4. Qualitative and quantitative methods of nutritional assessment

Suggested Readings

1. Eaton, S. B., & Konner, M. (1985). Paleolithic nutrition: a consideration of its nature and current implications. *The New England Journal of Medicine*, 312(5):283-289.
2. Farb, P. & Armelagos, G. (1980). *Consuming Passions: The Anthropology of Eating*. Boston: Houghton Mifflin Co. Pp. 3-14.
3. Hunter, J. M. (1973). *Geophagy in Africa and in the United States: A Culture-Nutrition Hypothesis*. Geographical Review, 63:170-195.
4. Jenkins, M. (2002). *Burgerstein's Handbook of Nutrition: Micronutrients in the Prevention and Therapy of Disease*.
5. Leonard, W. R. (2002). Food for thought: dietary change was a driving force in human evolution. *Scientific American*, 287:106-112.
6. Pelto, G. H., Goodman, A. H., & Dufour, D. L. (2000). The biocultural perspective in nutritional anthropology. In: Goodman AH, Dufour DL, Pelto GH. (eds.) *Nutritional Anthropology: biocultural Perspectives on Food and Nutrition. Mountain View*, CA: Mayfield Publishing Co. Pp. 1-9.
7. Teaford, M. F., & Ungar, P. S. (2000). Diet and the evolution of the earliest human ancestors. *Proceedings of the National Academy of Sciences*, 97:13506–13511.

Teaching Learning Process
The students will be encouraged to prepare FFQs through questionnaires. Somatometric techniques will be used to assess the nutritional status.

Assessment Methods
Examination schemes and mode shall be as prescribed by the Examination Branch, University of Delhi from time to time.

Keywords
Nutritional Assessment, Micro and Macro-nutrients, Malnutrition, Lifestyle Diseases

SEMESTER-5

BSc. (Hons.) Anthropology

DISCIPLINE SPECIFIC CORE COURSE -13 (DSC-13)
Anthropology of Health and Wellbeing

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Anthropology of Health and Wellbeing	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objectives

1. To explore various dimensions of health and issues related to illness and disease.
2. To familiarize the students with various demographic measuring methods and their applications.
3. Aims to provide knowledge about the cultural dimensions of illness, disease, and health in Indian context.

Learning Outcomes

Students will be able to:

1. comprehend the application of the concept of health, illness, and disease.
2. handle basic demographic and medical anthropological methods to evaluate demographic and health assessment.
3. grasp, analyse and interpret health, illness, disease related issues and develop critical understanding.

Syllabus:

Unit-1: Introduction (10 Hours)
Anthropology and health; Medical Anthropology and its subfields; Approaches, health and its determinants, dimensions and indicators

Unit-2: Disease, Illness and Healing (11 Hours)
Concept of Disease and Illness; Experiential Health – Indian perspective: placebo, faith healing; Measuring Health: Morbidity and Mortality: Healing and Healers in Cross-Cultural Perspectives, Ethno-medicine

Unit-3: Mental Health and Wellbeing (12 Hours)
Culture and Mental Health, Ethno-psychiatry, Concept of wellbeing and quality of life; Happiness Life Index

Unit-4: Public Health and Anthropology (12 Hours)
National Health Policy, Health Care Programmes in India; Mother and Child Health: Women's Health, New-born's health, Family Planning; Endemics, Epidemics, and Outbreaks; Pandemics and Communicable diseases; Health and Environment

Practical (30 Hours)
Project on Health-related issues based on primary/secondary data collection through fieldwork/review of literature.

References

1. Farmer, Paul, Jim Yong Kim, Arthur Kleinman and Matthew Basilico (2013) *Reimagining Global Health*, University of California Press

2. Gaur, Mokshika and Soumendra. Patnaik (2011). Who is healthy among the Korwa?" Liminality in the experiential health of the displaced Korwa of Central India, *Medical Anthropology Quaterly*, Mar;25(1):85-102.

3. Hahn, Robert A. 1999. *Anthropology in Public Health. Bridging Differences in Culture and Society.* New York: Oxford University Press.

4. Helman, Cecil G. 1994. *Culture, Health, and Illness*. 3rd ed. Oxford.

5. Inhorn, Marcia C; Wentzell, Emily A (2012). *Medical Anthropology at the Intersections: Histories, Activisms and Futures*. Duke University Press Books

6. Mehrotra, Nilika & Mahima Nayar (2015). *Isliye dard hota hai*: Women's Mental Health Issues in Poor Households of India, *Psychology and Developing Societies*, vol. 27 no. 1 104-124.

7. Tsui, Amy O., Judith N. Wasserheit, and John G. Haaga (eds.) (1997). *Reproductive Health in Developing Countries*. Washington, D.C.: National Academy Press.

8. Winkelman M (2008). *Culture and Health: Applying Medical Anthropology*. Jossey-Bass

Teaching Learning Process
The process of learning will involve acquisition of disciplinary knowledge and understanding of skills required for a researcher exploring health, illness, and disease. The process will involve lecture, class-room exercises, project-based learning, data collection and analysis, fieldwork and report preparation and presentation.

Assessment Methods
Examination schemes and mode shall be as prescribed by the Examination Branch, University of Delhi from time to time.

Keywords
Health, Illness, Disease, Health Policy, Health Dimensions

DISCIPLINE SPECIFIC CORE COURSE -14 (DSC-14)
Religion and Economy

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Religion and Economy	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objective

The objective of the paper is to understand about various religious life and the economic life in diverse society using a comparative framework.

Learning Outcomes

By studying the paper, the students will be able to:

1. demonstrate understanding of various dimensions of religion, the rituals activities, etc.
2. identify the economic activities among traditional societies.
3. analyze the factors of changes regarding religious and economic life spheres.

Syllabus:

Unit 1: (10 Hours)

Concept and Meaning of Religion, Systems of Faith; distinction between Dharma and religion; Religious Symbols; Approaches to study religion: Types and forms of religious life.

Unit 2: (11 Hours)

Magic, religion and science; revivalism and conversions, religious pluralism and social harmony.

Unit 3: (12 Hours)

Concepts and Approaches; Reciprocity, Redistribution and Market: Ceremonial exchange, Gifts; Barter, Trade, Weekly Market, Money, Mela and Festivals.

Unit 4: (12 Hours)

Changes in Economic Patterns: Technology, Innovation, Trade; Traditional entrepreneurship/ Household and Cottage Industries; Temple economy and other institutions.

Practical (30 Hours)

1. Prepare a project on any social institutions (religion or economy) considering the socio-cultural aspects in our society.

2. Identify and review an ethnography/monograph revealing significant socio-cultural and economic imperative in the community.

References

1. Bielo, James. S. (2015). *Anthropology of Religion: The Basics*. Routledge Publishing.
2. Gottlieb, R. (2004). *This sacred earth: religion, nature, environment*. Routledge
3. Hann, Chris & Keith Hart. (2011). *Economic Anthropology: History, Ethnography, Critique*. Polity Press.
4. King, E. Francis. (2009). *Material Religion and Popular Culture.* Routledge
5. Lambek, Michel. (2008). *A reader in Anthropology of Religion*. Wiley Blackwell, UK
6. Madan, T.N. (2011). *India's Religions: Perspectives from Sociology and History*. Oxford University Press.
7. Malinowski, B.(1967) *Argonauts of the Western Pacific*. London: Routledge and Kegan Paul

Teaching Learning Process

Classroom teachings
Seminars, presentations and group discussion Practical classes

Assessment Methods:
Examination schemes and mode shall be as prescribed by the Examination Branch, University of Delhi from time to time.

Keywords:

Religion, Symbols, Totemism, Exchange, Barter

DISCIPLINE SPECIFIC CORE COURSE -15 (DSC-15)
Village and City in India

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Caste, Village and Cities in India	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objectives

The students will be introduced to the problems associated with concept of peasant in India. The focus will be on the contemporary issues and challenges that confront the rural communities in India.

Learning Outcomes

The students will be able to:

1. demonstrate understanding of the problems and challenges relating to agrarian societies both in historical and contemporary perspectives.
2. describe the changing patterns of village life.
3. evaluate policy pertaining to agrarian reforms and migration.
4. identify remedial measures for city environmental problems.

Unit 1: (10 Hours)

Varna and *Jati*, Indological and empirical approaches, book-view and field-view, caste mobility, contemporary debates

Unit 2: (11 Hours)

Social Organization of an Indian village: Village studies in Anthropology. Institutions, economy and changes; Globalisation and the Indian village

Unit 3: (12 Hours)

Peasantry: Concept and approaches to the study of peasants. State Policy and Agrarian Reform, agrarian transformation, rural–urban migration

Unit 4: (12 Hours)

Emergence of city, study *in* and study *of* city, Folk-urban continuum, approaches and methodologies in urban anthropology; Urban Social Structure: problems and challenges

Practical (3 0 Hours)

1. Identification of a problem related to rural communities and peasant societies of Indian Villages. Preparation of a research design for a detailed study.
2. Field visits in different parts of the city to understand various facets of community life, with special reference to changing caste dynamics.
3. Visit a residential colony and study their urban neighbourhood relationship.

Suggested Readings

1. Dube S.C. (1955). *Indian Village*. London: Routledge and Kegan Paul Ltd

2. Fox. R. G. (1977). *Urban Anthropology: cities and their cultural Setting*. University of Michigan: Prentice Hall

3. Hannerz U. (1983). *Exploring the city inquires towards an urban anthropology*. New York: Columbia University Press.

4. Jodhka, Surinder S (ed.); Simpson, Edward (ed.). (2019). *India's villages in 21st century*. New Delhi: Oxford University Press.

5. Low, Setha. (2005). *Theorizing the City: The New Urban Anthropology Reader*. New Jersey: Rutgers University Press.

6. Shanin T. (1987). *Peasants and Peasantry*. New York: Blackwell.

7. Srinivas, M. N. (2000). *Caste: Its twentieth Century Avatar*. New Delhi: Penguin.

Teaching Learning Process
Lectures and Discussions
Seminars and Presentations

Assessment Methods:
Examination schemes and mode shall be as prescribed by the Examination Branch, University of Delhi from time to time.

Keywords:
Caste, Village, Rural, Urban, City, Slum, Agrarian, Folk-urban

POOL OF DISCIPLINE SPECIFIC ELECTIVES

DISCIPLINE SPECIFIC ELECTIVE COURSE -9 (DSE-9)
Primate Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Primate Biology	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objectives

The objective of this paper is to enable the students to understand the evolutionary biology of various non-human primates. Their physical and anatomical metamorphosis will help the students to understand primate evolution too.

Course Learning Outcome:

The students will be able to:

1. demonstrate understanding of human evolution and origin.
2. comprehend the physical aspects that can be used for better understanding of early human migration.

Syllabus:

Unit 1(10 Hours)

History, aim and scope of Primate Biology and its importance in anthropology

Unit 2 (11 Hours)

Definition of primates, characteristic features, classification, primate radiation and primate locomotion

Unit3 (12 Hours)

Anatomical differences between Prosimians and Anthropoids, Old and New World monkeys, Great and Lesser apes and Humans

Unit 4 (12 Hours)

Human Evolution: Dryopithecus, Ramapithecus, Australopithecus, Homo habilis, Homo erectus, Homo sapiens, Neandertalensis, Homo sapiens sapiens

Practical (30 Hours)

Identify and draw the skull/crania of: Prosimians, Anthropoids, Old and New World monkeys, Lesser and greater apes and humans for comparisons with anatomical features.

References:

1. D. Swindler (2004). *Introduction to the primates*. Indian Overseas Press.
2. John Buettner-Janusch (1966). *Origins of Man: Physical Anthropology*. Willey Eastern Publication Ltd.
3. Pia Nystrom and Pamela Ashmore (2011). *The Life of Primates*. Prentice Hall India Learning Private Limited.
4. Russell, Tuttle. (2007). *The functional and Evolutionary Biology of Primates*. Aldine Transaction.
5. Winfried Henke and Ian Tattersall (2015). *Handbook of Palaeoanthropology*. Springer Berlin, Heidelberg.

Teaching Learning Process

Classroom teachings, Seminars, presentations and group discussion, Practical classes

Assessment Methods:
Examination schemes and mode shall be as prescribed by the Examination Branch, University of Delhi from time to time.

Keywords: Non-human primates, primate radiation, primate locomotion

DISCIPLINE SPECIFIC ELECTIVE COURSE -10 (DSE-10)
Visual Anthropology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Visual Anthropology	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objectives
This course is designed to help students understand how anthropologists have used visual methods to produce anthropological knowledge; it will also help students learn to critically analyse visual media and produce visual images and films that are anthropologically informed.

Learning Outcomes
On completion, students will be able to:

1. demonstrate understanding of the inter-disciplinary nature of studying visuals in anthropology.
2. analyze visual and textual ethnographic representation in different theoretical traditions.
3. make anthropologically informed documentary films.

Syllabus:

Unit 1 Situating Visual Anthropology (10 Hours)

Historical and Contemporary Trajectories; Interdisciplinarity; Visual Anthropology and the Senses

Unit 2 Theory and Representation (11 Hours)

Social Theory of Communication and Ethnographic Semiotic; Theories of Representation; Politics and Poetics of Representation; Indigenous Filmmaking and Self Expression

Unit 3 Ethnographic Photography and Pictorial Media (12 Hours)

Photographic analyses; Images as writing; Found Images; Photography as tool of ethnographic observation; Indigenous Media

Unit 4 Ethnographic Films: Techniques and Ethics (12 Hours)

Ethnographic film as sensory experience; techniques of Ethnographic Film making; Ethical Issues

PRACTICAL(30 Hours)

1. Photo analysis: Analyze visual data from classical and contemporary ethnographies signifying how ‘otherness’ is constituted in different theoretical traditions.
2. Photo-elicitation and Ethno-photo essay
3. Auto-Ethnographic Digital Storytelling
4. Short ethnographic/documentary filmmaking and their anthropological evaluation.

REFERENCES

1. Banks, M and J. Ruby. (eds). (2011). *Made To Be Seen: Perspectives on the History of visual anthropology.* Chicago: University of Chicago Press.

2. Banks, M. (2001). *Visual Methods in Social Research*. London: Sage Press

3. El Guindi, Fadwa. (2015). ‘Visual Anthropology: Essential Method and Theory’. In H.Russell Bernard and Clarence C. Gravlee (eds) *Handbooks of Methods in Cultural Anthropology*. Lanham: Rowman and Littlefield.

4. Hockings, Paul. (2003). *Principles of Visual Anthropology*. Berlin: Mouton de Gruyter.

5. Lawrence, Andy. (2020). *Filmmaking for fieldwork: A practical handbook.* Manchester University Press

6. Pink, Sarah. (2010). *Doing Sensory Ethnography*. Sage Publications.

7. Worth, Sol and Larry P Gross. (1981). *Studying Visual Communication*. Philadelphia: University of Pennsylvania Press.

Teaching Learning Process

Lectures and Discussions

Fieldwork for filmmaking

Hands-on practice in the Visual Anthropology Lab

Seminars and Presentations

Assessment Methods:

Examination schemes and mode shall be as prescribed by the Examination Branch, University of Delhi from time to time.

Keywords: Representation, Ethnographic Film, Visual, Communication, Sensory

DISCIPLINE SPECIFIC ELECTIVE COURSE -11 (DSE-11)
European Prehistory

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
European Prehistory	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objectives

1. To introduce to students the evolutionary perspective of human prehistoric society in Europe with the help of archaeological cultural remains.
2. To familarise the students with tool typology and its classification for the reconstruction of prehistoric societies.

Learning Outcomes

By studying this course, students will be able to:

1. describe the landscape of European archaeological sites and their relevance in studying prehistoric societies.
2. identify the tools, appreciate the tool typology, and classify it appropriately.

Syllabus:

Unit I (10 Hours)
Introduction to European Prehistory: Chronology and Terminology.

Unit II (11 Hours)
Lower Palaeolithic Culture of Europe: Somme Valley, Terra Amata, Le Vallonet, Monte Poggiollo, Atapuerca, Toralba -Ambrona

Unit III (12 Hours)
Middle Palaeolithic Culture of Europe: Le Moustier, Gorham Cave, Asprochaliko and Kiik Koba, Tata, La Micoque

Unit IV (12 Hours)
Upper Palaeolithic Culture of Europe: Different types of traditions. Cave Art

References:

1. Bhattacharya, D.K. (1977). *Palaeolithic Europe*. Netherland: Humanities press.

2. Champion Timothy, Clive Gamble, Stephen Shenan & Alasdair Whittle (2009) *Prehistoric Europe*, London: Routledge

3. Debenath, A., & Dibble, H. (1994). *Handbook of Paleolithic Typology. Volume one: Lower and Middle Paleolithic of Europe.* Philadelphia: University of Pennsylvania.

4. Fagan B. M. (2004). *People of the Earth: An Introduction to World Prehistory*. New Jersey: Pearson Education.

5. Gamble Clive. (1999). *The Paleolithic Societies of Europe*. Cambridge-. Cambridge University Press.

6. Hole, F., & Heizer, R. F. (1969). *An Introduction to Prehistoric Archaeology*. New York: Holt, Rinehart and Winston

Practical/Project work/Assignment (30 Hours)

- Identification of tools:
  Chopper/chopping tools
  Varieties of handaxes
  Cleavers and its types
  Side scrapers
  End scrapers
  Knives
  Burins
  Borers
  Microliths
  Bone tools

- Identification of various lithic technologies

Teaching Learning Process
The process of learning will involve acquisition of domain knowledge and understanding of skills required for conducting research in European archaeology. Process will involve lectures, assignments, class-room discussions, practical and appropriate inference of results and practical file preparation.

Assessment Methods
Examination schemes and mode shall be as prescribed by the Examination Branch, University of Delhi from time to time.

Keywords
Geochronology, European archaeology, tool culture in Europe

SEMESTER-VI
Bachelor of Science (Hons) Anthropology

DISCIPLINE SPECIFIC CORE COURSE -16 (DSC-16)
Human Population Genetics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Human Population Genetics	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objectives
1. To understand the basic tenets of human population genetics
2. To learn the concepts of evolutionary forces and their applications
3. To understand the role of human genetic variation in shaping current population structure

Learning Outcomes
The students will be able to:
- develop basic understanding of genetic principles of human populations
- understand the concept of polymorphisms and its applications in understanding genetic structure of human populations
- develop an idea of different types of evolutionary forces
- understand the role of genetic variations in studying human populations

Syllabus:

Unit-1 (10 Hours)
Landmarks in the history of population genetics, Concept of genetic polymorphism; haplotypes and haplogroups; transient, balanced polymorphisms; single locus versus multi-locus inheritance and population structure

Unit-2 (11 Hours)
Genotypic and allelic frequencies, assumptions of Hardy-Weinberg equilibrium, and its applications

Unit-3 (12 Hours)
Concept of Mutation, Natural Selection, Genetic drift, Gene flow, admixture and inbreeding

Unit-4(12 Hours)
Models explaining the maintenance of genetic polymorphism (Relationship between sickle cell and malaria, X-linked polymorphism and selection relaxation hypothesis)

Practical (30 Hours)
1. Blood group typing-ABO; MN and Rh (D) blood groups
2. Color Blindness
3. Blood Collection, sample transportation
4. Plasma and RBC separation and storage in field

References

1. Vogel F. and Motulsky A.G. (1996). Human Genetics: Problems and Approaches. Springer, 3rd revised edition.
2. Cooper DN and Kehrer-Sawatzki H. (2008). Handbook of Human Molecular Evolution. John Wiley & Sons, volume-2.
3. Lewis R. (2009). Human Genetics: Concepts and Applications 9th Edition. The McGraw−Hill Companies, Inc.
4. Patch C. (2005). Applied Genetics in Healthcare. Taylor & Francis Group
5. Templeton A. R. (2018). Human Population Genetics and Genomics. Academic Press.

Teaching Learning Process

The process of learning will involve acquisition of domain knowledge and understanding of skills required for conducting research in human population genetics. Process will involve lectures, assignments, class-room discussions, laboratory experiments and appropriate inference of results and practical file preparation.

Assessment Methods

Theoretical understanding of the student will be assessed using time-constrained examination. The assessment of the practical will be based on the conducting the laboratory-based experiments, inference of results and practical file preparation.

Keywords

human genetics, DNA, genetic structure, human evolution, natural selection, genetic drift

DISCIPLINE SPECIFIC CORE COURSE -17 (DSC-17)
Tribes of India

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Tribes of India	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objectives

The course is designed to help students understand the contested and problematic nature of the term ‘tribe’ and its definitional attributes. It also seeks to elucidate pressing issues faced by the tribes in India by focus on the contemporary issues, challenges and crisis that confront the rural and tribal communities in India.

Learning Outcomes

At the end of the course, the student will be able to **:**

- comprehend the nature and concepts of tribe and indigenous communities in comparison to caste societies.
- understand critical issues, problems and challenges related to tribal societies both in historical and contemporary perspectives.
- understand the challenges of tribal development and associated solutions.

Syllabus:

Unit 1: On the concept of tribe (10 Hours)

Concept and approaches to the study of tribes; classification, distribution and cosmogeny of tribes in India; Scheduled Tribes, *Adivasi* and Indigenous people; Particularly Vulnerable Tribal Groups , De notified communities

Unit 2: Tribes and institutions (11 Hours)

Kinship system, types of family, rules of marriage, tribal polity and governance, subsistence economy and tribal market, tribal religion: nature-man-spirit complex, Gender and Tribe

Unit 3: Issues in Tribal Development (12 Hours)

Problems of tribal communities in different parts of India; Displacement and Rehabilitation. Protest movements; Modernization, Globalization and Tribal Transformation

Unit 4: Tribes and Policy (12 Hours)

National Tribal Policy; Forest Rights, Food security, land acquisition, mining, tribal migrants

Practical (30 Hours)
The students shall prepare comprehensive project based on short fieldwork or from secondary sources on different dimensions of tribal life.

References:

1. Bailey, F.G. (1960). *Tribes, Caste and Nations*. Manchester University Press
2. Bhandari, J. S., and Subhadra Channa. (1997). *Tribes and government policies*. New Delhi: Cosmo Publications.
3. Channa, Subhadra Mitra. (2020). *Anthropological Perspectives on Indian Tribes*. New Delhi: Orient Blackswan Private Limited.
4. Chaudhury, Sukant K., and Patnaik, Soumendra Mohan. (2008.) *Indian Tribes and the Mainstream*. New Delhi. Rawat Publications.
5. Fürer-Haimendorf, Christoph von. (1985). *Tribal populations and cultures of the Indian subcontinent*. Handbook of Studies Oriental Leiden: E.J. Brill.
6. Miri, Mrinal. (2003). *Identity and the moral life*. New Delhi: Oxford University Press.
7. Vidyarthi, L.P.(2011 online). *The Maler : A study in Nature-Man -Spirit Complex of a Hill Tribe* (Bookland : Calcutta 1963) Cambridge University Press (Online)
8. Xa-xa, Virginius. (2008). *State, Society, And Tribes: Issues In Post-Colonial India*. New Delhi: Dorling Kindersley (India)

Teaching Learning Process
Lectures and Discussions
Seminars and Presentations

Assessment Methods:
Practical assignments/ project reports; theory, and practical examination at the end of term.

Keywords:
Scheduled Tribe, Caste, Tribal Development, Tribal Policy, Indigenous People

DISCIPLINE SPECIFIC CORE COURSE -18 (DSC-18)
Anthropological Fieldwork

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Anthropological Fieldwork	04	02	Nil	02	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course objective

To train students to apply the methods and techniques of fieldwork in actual field situation to understand social problem and lived realities in a tribal or a rural community.

Learning Outcomes

The students will be able to:

- apply the theoretical perspectives in actual field situation and systematically undertake a study on an anthropological problem.
- write a report based on the field data using qualitative and quantitative methods.

Syllabus:

UNIT 1. Identification of a community for fieldwork, collection of secondary information and preparation of field statements, designing the field study, identification and formulation of research tools, pre-testing and standardization of research tools. **(07 Hours)**

UNIT 2. Survey methods: formation and administration of household census to collect data on socio-economic and biological variables. **(07 Hours)**

UNIT 3. Ethnographic methods: Team Ethnography, rapport establishment, categories of respondents, sources of data, maintaining field diaries and field notes, ethical considerations **(08 Hours)**

UNIT 4. Collection of data on biological variables and their analyses. **(08 Hours)**

Practical (60 Hours)

Students are required to apply these techniques and methods in real social context to have variable experience and make sense of how to use them in research context.

Students will undertake fieldwork of 10-12 days to any rural or tribal area and explore significant dimensions of the community life involving anthropological techniques.

Students are required to submit a dissertation based on the fieldwork taking into account cultural and biological variables.

References:

1. Brewer, John David. 2000. *Ethnography: Understanding Social Research*. Open University Press.
2. O'Reilly, Karen. 2012. *Ethnographic Methods*. Routledge.
3. Patnaik, Soumendra M. *Doing Team Ethnography. 2006 The Eastern Anthropologist* 59 (3-4): 295-319.
4. Srivastava, Vinay Kumar. 2004. *Fieldwork and Methodology*. Oxford University Press. New Delhi
5. Madan, T. N., Beteille, André. 1975. Encounter and Experience - Personal Accounts of Fieldwork. Vikas Publishing House.

Teaching and Learning process:

Lectures and Discussions, Field visits, Presentations

Assessment methods: Viva voce examination based on submitted dissertation.

Keywords: Ethnography, Field study design, field research tools, report writing

POOL OF DISCIPLINE SPECIFIC ELECTIVES

DISCIPLINE SPECIFIC ELECTIVE COURSE -12 (DSE-12)
Research Methods in Anthropology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Research Methods in Anthropology	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objectives

1. To understand the process of designing an effective research study in anthropology
2. To learn the qualitative and quantitative methods used in anthropological research
3. To learn the appropriate ways of scientific writing

Learning Outcomes

The students will be able to:

- understand how to formulate research problem and able to frame it for the purpose of research
- use qualitative and quantitative methods used in anthropological research
- know the ways of scientific writing and sensitive to ethical issues such as intellectual honesty and plagiarism.

Syllabus:

Unit-1: Research Designs (09 Hours)

Types of Research Design- Exploratory, Description and Experimental, Formulation of research problem, hypothesis, review of literature and conceptual framework

Unit-2: Ethnographic research (09 Hours)

Ethnographic and survey research distinguished, etic and emic perspectives, comparative and historical methods, techniques of rapport establishment, identification of representative categories of informants, maintenance of field diary and logbook

Unit-3: Tools and techniques of data collection (09 Hours)

Formulation of questionnaire, interview schedule and interview guide, types of Interview - structured, unstructured and semi-structured, observation and its types, participant observation, Focused Group Discussion, key informant interview; Case Study, life history and genealogy.

Unit-4: Ethics and Human Research (09 Hours)

Ethical issues in social science and human subject research.
Concepts, guidelines and practice

Issues of Plagiarism, conflicts of interest and publication ethics

Unit-5: Bio-Statistics and its Applications (09 Hours)
Types of variables, Measurers of Central Tendency, Measures of Dispersion, Skewness and Kurtosis and Normal distribution; Concept of metanalysis.
Geospatial mapping and use of satellite data in anthropological research

Practical (30 Hours)
Project report based on data collection related to anthropological topic.

References

1. Madrigal L. 2010. Statistics for Anthropology. Cambridge: Cambridge University Press. 2012. Zar JH. Biostatistical Analysis. Prentice Hall.
2. Bernard H.R. 2006 Research Methods in Anthropology, Qualitative and Quantitative Approaches. Jaipur: Rawat Publications.
3. Emerson RM, Fretz RI and Shaw L. 1995. Writing Ethnographic Fieldnotes. Chicago, University of Chicago Press.
4. Garrard E and Dawson A. What is the role of the research ethics committee? Paternalism, inducements, and harm in research ethics. Journal of Medical Ethics 2005; 31: 419-23.
5. Patnaik , Soumendra Mohan 2013 . Ethical Debate in Development Discourse in India : Towards Formulation of Universal Ethical Guidelines . Developmental Anthropology ; *Entwicklungsethnologie* Vol 21 no 1&2 Hamburg /Germany

Teaching Learning Process
The process of learning will involve acquisition of disciplinary knowledge and understanding of skills required for anthropological research. Process will involve lectures, project based learning, designing a research study, data collection with the help of fieldwork and report submission.

Assessment Methods
Theoretical understanding of the student will be assessed using time-constrained examination. The assessment of the practical will be based on the quality of the project report submitted by the student (i.e., involvement of the student in every aspect of the report preparation for example, development of tools for data collection, fieldwork, data entry, analyses and writing).

Keywords
Research, anthropology, ethnography, biostatistics, ethics

DISCIPLINE SPECIFIC ELECTIVE COURSE -13 (DSE-13)
Kinanthropology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Kinanthropology	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objectives

1. To provide the applied knowledge of biological anthropology in an inter-disciplinary framework with respect to performance, exercise and nutrition.
2. The course equips theoretical & applied aspects of kinanthropology.

Learning Outcomes

The students will be able to:

- Learn the tools and techniques of kinanthropology that can help understanding growth, exercise, performance and nutrition.
- understand an integrated approach for use in the field of Physical Education, sport, recreation, rehabilitation and physiotherapy.

Unit I: History, Concept and Scope(10 Hours)
History and development of Kinanthropology. Basic concept and techniques. Scope and relevance

Unit II: Kinanthropology and other disciplines(11 Hours)

Relevance of kinanthropology in Physical education, sports, public health

Unit III: Tools & techniques in Kinanthropology (12 Hours)

Traditional & modern methods in Kinanthropology

Unit IV: Application of Kinanthropology (12 Hours)
Kinanthropometry, Growth, Exercise, Performance, Nutrition

Practical (30 Hours)

1. **Somatometric measurements:** Stature, Sitting Height, Body weight, Head length, Head Breadth, Head Circumference, Nasal height, Nasal breadth, Total Upper Extremity Length Size, Total Lower Extremity Length, Hand Grip Strength, Skinfold at Triceps, Skinfold at Biceps
2. **Indices:** Body mass index, Relative sitting height, Relative upper extremity length, Relative total lower extremity length, Nasal index, Cephalic index
3. Projects on topics related to kinanthropology. on current issues around innovative ideas.

References

1. Singh, S.P., & Mehta, P. (2009). Human Body Measurements: concepts and application. PHI Learning Pvt. Ltd.
2. Physical activity and Growth by RJ Shephard, 1982 (Mosby).
3. Singh I.P., & Bhasin, M. K. (Digital version 2008). Anthropometry. Kamla-Raj Enterprises.
4. Renson,R. (1989). From Physical Education to Kinanthropology: A Quest for Academic and Professional Identity. QUEST (41) 235-256.
5. Human Body Composition by Heymsfield, Lohman, Wang and Going. 1996 (Human Kinetics).
6. Human Body Composition by Heymsfield, Lohman, Wang and Going. 1996 (Human Kinetics).

Teaching Learning Process

Classroom teachings, Seminars and presentations, Practical classes, Workshop

Assessment Methods

Theory and practical examinations (including practical records)

Keywords: Kinanthropometry, physical fitness, sports, human growth, exercise

DISCIPLINE SPECIFIC ELECTIVE COURSE -14 (DSE-14)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Psychological Anthropology	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objective

The course examines the cultural, evolutionary and psychological basis of human behaviour. It attempts to bring in the cultural basis of some of key psychological concepts like self, identity, emotion, and others that influences human cognition and behaviour and the psychological basis of cultural behaviour, it also looks at cultural aspects of Mental disorders.

Learning Outcomes

The course would enable the students to:

- understand the cultural, evolutionary and the psychological basis of the key concepts of mind, body and culture.
- comprehend the universals in human behaviour and how these universals are influenced by the culture and other factors.

Unit1. Concepts of Human Nature, Body, Brain, Mind and Culture. **(10 Hours)**

Foundations of human behaviour: cultural, evolutionary and psychological dimensions.

Unit 2: Culture and Personality Studies; Basic personality, Modal personality, National Character studies **(11 Hours)**

Unit 3: Concepts of Self, Identity, Emotions **(12 Hours)**

Unit 4: Psychiatric anthropology and mental wellbeing; Altered states of consciousness: spirit possession, shamanism and faith healing **(12 Hours)**

Practical (30 Hours)

1. Students are required to conduct interviews and assess the psychological profile of the respondents in given cultural context.

2. Exploration of issues pertaining to the idea of personhood, interpersonal relationship and cultural orientations in the life of the respondents.

3. A brief report is to be prepared on any specific topic having relevance to psychological anthropology.

Suggested Readings:

1. Imgham, J. M. (1996). *Psychological Anthropology Reconsidered*. Cambridge: Cambridge University Press.

2. Eller, J.D. (2019). *Psychological Anthropology for the 21st Century*. NY and London: Routledge

3. Shweder, Richard A. and Robert A. LeVine, eds. (1984). *Culture Theory: Essays on Mind, Self and Emotion*. Cambridge: Cambridge University.

4. Spiro, Melford E. (1987). *Culture and Human Nature: Theoretical Papers of Melford E. Spiro.* Benjamin Kilborne and L.L. Langness, eds. Chicago: University of Chicago Press.

5. Strauss, Claudia and Naomi Quinn 1(997). *A Cognitive Theory of Cultural Meaning*. Cambridge: Cambridge University Press.

6. Nayar, Mahima. (2018). *Against all odds: Psychosocial distress and healing among women.* New Delhi: Sage Publications

7. Mathur, Nita. (2002). *Cultural rhythms in emotions, narratives and dance*. New Delhi: Munshiram Manoharlal

Teaching Learning Process

Lectures and Discussions, Seminars and Presentations

Assessment Methods:

As per University Rules

Keywords:

Emotions, Identity, Altered states of consciousness, personality, shaminism

DISCIPLINE SPECIFIC ELECTIVE COURSE -15 (DSE-15)
Post Holocene Cultural Adaptations of India and Europe

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Post Holocene Cultural Adaptations of India and Europe	04	03	Nil	01	Class XII pass	NIL

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objectives

- The course aims to understand the cultural adaptations of societies in India and Europe with the help of archaeological and cultural remains.

Learning Outcomes

- By studying this course, students will be able to understand the landscape of archaeological sites and their relevance in studying cultural adaptations in prehistoric societies in Europe and India.

Syllabus

Unit I (10 Hours)

Introduction to Holocene Epoch: Geo-chronology, climate change, fauna and flora

Unit II (11 Hours)

Mesolithic Culture of India at Bhimbhetka, Adamgarh, Bagor, Langhnaj and Sarai Nahar Rai.

Rock Art of India

Unit III (12 Hours)

Neolithic Culture of India at Burzahom

Evidences from Ganga Valley and Eastern India, Deccan Neolithic

Unit IV (12 Hours)

Mesolithic Culture of Europe: Different Traditions: Azilian, Maglamosean, Tardenosean

References:

1. Bhattacharya, D.K. (1977). Palaeolithic Europe. Netherland: Humanities Press.

2. Hole, F., & Heizer, R. F. (1969). An Introduction to Prehistoric Archaeology. New York: Holt, Rinehart and Winston
3. Bailey, G. and P. Spikins (eds.). (2008). Mesolithic Europe. Cambridge-. Cambridge University Press.
4. Fagan B. M. (2004). People of the Earth: An Introduction to World Prehistory. New Jersey: Pearson Education.
5. Debenath, A., & Dibble, H. (1994). Handbook of Paleolithic Typology. Volume one: Lower and Middle Paleolithic of Europe. Philadelphia: University of Pennsylvania.
6. Champion Timothy, Clive Gamble, Stephen Shenan & Alasdair Whittle (2009) Prehistoric Europe, London: Routledge
7. Bhattacharya, D.K. (2006).An Outline of Indian Prehistory. Delhi: Palaka Prakashan.
8. Sankalia, H. D. (1977). Prehistory of India. Delhi: Munshiram Manoharlal.

Practical/ Assignment/Project Work (30 Hours)

The students are required to submit a comprehensive project report based on the state of art review of secondary literature on significant dimensions of post-holocene cultural adaptations in India and Europe.

Teaching Learning Process

Lectures and Discussions, Seminars and Presentations

Assessment Methods:

As per University Rules

Keywords: Prehistoric archaeology, palaeolithic culture, mesolithic culture

SEMESTER-IV

Category I

(SRI VENKATESWARA COLLEGE)

(BSc Honors in Biological Science in three years)

DISCIPLINE SPECIFIC CORE COURSE – 10:

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Metabolism and Integration (BS-DSC-401)	4	2		2	Class XII Pass with Biology and chemistry	Should have a background in chemistry of biomolecules and enzymes

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the students to the basic concepts of metabolism occurring within a living organism.
- to provide the students an understanding of the major metabolic pathway and their regulation.
- To provide knowledge about the possible integration between various metabolic pathways.
- To enable them to corelate adaptations in metabolic pathways and physiological as well as pathophysiological states.

Learning outcomes

On successful completion of the course, students will be able to:

- Outline the pathways involved in catabolism and biosynthesis of glucose.
- Understand the biosynthesis and degradation of glycogen
- Comprehend the catabolism and biosynthesis of fatty acids
- Understand the biosynthesis and degradation of amino acids and nucleotides
- Understand the integration of metabolism

SYLLABUS FOR DSC-10

CREDITS:2 **TOTAL HOURS: 30 hrs**

UNIT I: Carbohydrate metabolism **No. of hours: 14**

Principles of metabolism, anabolism, catabolism, standard free energy change, metabolic roles of ATP, phosphoryl group transfer, nucleotidyl group transfer. Glycolysis as a universal pathway, anaerobic glycolysis, fermentation, gluconeogenesis, reciprocal regulation of glycolysis and gluconeogenesis, Glycogenesis and glycogenolysis and overview of regulation, Pentose phosphate pathway, Pyruvate dehydrogenase complex, oxidation of acetyl CoA. TCA cycle, amphibolic role, ATP calculation, Glycerol-3-phosphate and malate-aspartate shuttle.

UNIT II: Lipid metabolism **No. of hours: 8**

Lipid metabolism - Mobilization of triglycerides, metabolism of glycerol, β-oxidation of saturated, monounsaturated and poly-unsaturated fatty acids, even and odd chain fatty acids. Ketogenesis and significance, Biosynthesis of C-16 palmitic acid, brief overview of cholesterol metabolism and lipoprotein cycle.

UNIT III: Amino acid and nucleotide metabolism **No. of hours: 5**

Transamination and deamination, Urea cycle, glucogenic and ketogenic amino acids, secondary metabolites from amino acids. Nucleotide Metabolism- De novo and Salvage pathways and degradation. Inborn errors of metabolism - Phenylketonuria, Alkaptonuria, Maple syrup, Lesch Nyhan syndrome.

UNIT IV: Integration of metabolism **No. of hours: 3**

Starve feed cycle: Metabolic shifts in absorptive, post absorptive, fasting and starvation states

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Estimation of Random Blood Glucose – Glucose Oxidase- Peroxidase method
2. Estimation of Oral Glucose tolerance test (O-GTT).
3. Determination of Lipid Profile: Total Cholesterol (TC), High Density Lipoproteins (HDL) and Triglycerides (TAG).
4. Estimation of SGPT and SGOT in serum/plasma sample.
5. Estimation of creatinine in serum/plasma sample.
6. Estimation of Blood Urea.
7. Estimation of serum uric acid

Essential Readings

1. Nelson, D.L. and Cox, M.M. (2017). Lehninger: Principles of Biochemistry (7th ed.). W.H. Freeman & Company (New York), ISBN:13: 9781464126116 / ISBN:10-1464126119.
2. Berg, J.M., Tymoczko, J.L., Stryer L., (2012) Biochemistry 7th ed., W.H. Freeman and Company (New York); ISBN:10:1-4292-2936-5, ISBN:13:978-1-4292-2936-4.
3. Campbell, M.K., Farrel, S.O. (2012) Biochemistry7th ed, S.O. Brooks/Cole, Cengage Learning (Boston); ISBN: 13:978-1-111-42564-7 ISBN:10:1-4292-2936-5.
4. An Introduction to Practical Biochemistry (1998) 3rd ed., Plummer D. T., Tata McGraw Hill Education Pvt. Ltd. (New Delhi), ISBN:13: 978-0-07-099487-4 / ISBN:10:0-07-099487-0

Suggested Readings

1. Principles of Biochemistry (2013) 4th ed., Voet, Donald,Voet, Judith &Pratt, charlotte. Wiley & Sons, Inc. (New Jersey), ISBN:978-1-11809244-6.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, Universityof Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 11

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Animal Physiology (BS-DSC-402)	**4**	**2**		**2**	Class XII pass with Biology and chemistry	**None**

Learning Objectives

The Learning Objectives of this course are as follows:

- Seeks to understand what the physiological adaptations are that enable animalsto thrive across virtually any environment on earth, and
- How some of these adaptations can reveal the general principles that govern life functions
- Provides an understanding of fundamental principles of animal physiology and how these principles are incorporated into adaptations of different animal groups.
- Emphasizes on integrating the knowledge of how systemswithin diverse organisms' function and respond to changes in their environment
- Serves as a comprehensive guide to understand the complexity of an organ system and to cover the comparative aspects of system in different animal groups.
- The course is based on the "Krogh's principle", which proposes the use of specific organisms convenient to study specific questions and to address the central concept based on evolutionary adaptations.

Learning outcomes

Upon completion of the course, the students will be able to:

- Students will know how animals obtain energy from their environment.
- Students will understand the unique role of various organs and organ systems inperforming various vital functions.
- Students will understand the role of physiology in adapting to various environments.
- Students will appreciate the importance of homeostasis in different animals.
- Students will learn to apply critical thinking and integrate scientific knowledge to understand the basic physiological principles which led to diverse evolutionary adaptations.

SYLLABUS OF DSC- 11

Theory

TOTAL HOURS: 30 **CREDITS: 2**

Unit 1: Production of Energy **No. of hours: 4**

Feeding patterns found in different animals; Intracellular and extracellular digestion, cellulose digestion in animals: invertebrates, ruminants, non-ruminants and coprophagy.

Unit 2: Gas Exchange in Organisms **No. of hours: 5**

Physiology of aquatic and terrestrial breathing; Respiratory organs in aquatic and terrestrial organisms: respiration in insects: terrestrial, aquatic and cyclic respiration, respiration in fishes: ventilation, water pumping and counter current flow, respiration in birds: air sacs, lung function and crosscurrent flow

Unit 3: Bulk Transport **No. of hours: 6**

General plan of circulatory system in invertebrates and vertebrates: closed and open system of circulation, single circulation and double circulation: circulation patterns of cockroach, bony fishes and amphibians. Physiology of vertebrate heart: cardiac output, regulation of heartbeat- Starling's law of the heart.

Unit 4: Regulatory Physiology **No. of hours: 10**

Homeostasis in animals: regulation of water and solutes in aquatic and terrestrial animals; osmoconformers and osmoregulators; physiology of osmoregulation in marine invertebrates, elasmobranchs and bony fishes (freshwater and marine); water balance in terrestrial animals: kangaroo rat.

Patterns of thermoregulation: heat exchange with the environment. Ectotherms: tolerance to high temperature (lethal temperature), tolerance to cold and freezing temperature (freeze tolerant and intolerant animals). Endotherms: thermogenesis and regulation of body temperature. Structural and functional adaptations to temperature stress (taking examples of arctic fox, penguins, and camels)

Unit 5: Integrative Physiology **No. of hours: 5**

An overview of neuronal structure and function; general principles of sensory physiology- chemoreceptors (gustatory and olfactory); mechanoreceptors (statocyst in invertebrates and lateral line system of fishes); sonar system in bats; electroreceptors (electric organs in fishes); thermoreceptors.

PRACTICALS

TOTAL HOURS: 60 **CREDITS: 2**

1. Effect of isotonic, hypotonic and hypertonic saline solutions on erythrocytes
2. Study of mouth parts and digestive system of *Periplaneta**
3. Preparation of temporary mounts: nerve cells and blood smear
4. Enumeration of Differential Leucocyte Count (D.L.C)
5. Effect of temperature on action of salivary amylase.

6. Study of permanent slides of nephridia of earthworm and mammalian oesophagus, stomach, ileum, rectum, liver, trachea, lung, kidney, spinal cord
   (*Subject to UGC guidelines)

Essential Readings

1. Moyes, C. D., & Schulte, P. M. (2008). Principles of Animal Physiology. San Francisco, CA: Pearson/Benjamin Cummings.
   2. Randall, D. C., Burggren, W. W., & French, K. (2002). Eckert Animal Physiology. New York: W. H. Freeman.
3. Schmidt-Nielsen, K. (2010). Animal Physiology: Adaptation and Environment. Cambridge: Cambridge University Press.

Suggested readings.

2. Prakash, G. (2012). Lab Manual on Blood Analysis and Medical Diagnostics. S. Chand andCo. Ltd.
3. Reece, J. B., & Campbell, N. A. (2011). Campbell Biology. Boston: Benjamin Cummings /Pearson.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE –12 :

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Physiology (BS-DSC-403)	**4**	**2**		**2**	Class XII pass with Biology and chemistry,	**None**

Learning Objectives

The Learning Objectives of this course are as follows:

- Gives the students an insight into the structure-function integration in plants.
- To appreciate the complex interactions of the plant with the environmental and edaphic factors that forms a major portion of plant physiology
- To provide students with comprehensive exposure to the subject of plant physiology.
- Aims to familiarize the students with the role of various functional processes of plants in their growth and development;
- To understand transport mechanisms and translocation in the phloem,
- Appreciate the commercial applications of plant physiology.

Learning outcomes

By the end of the course, the student will be able to:

- Comprehend the fundamental concepts of plant physiology
- Understand the physiological mechanisms of plant growth, function, and development.
- Understand the integration of soil, atmosphere, and plant in carrying outthe life processes by plants.
- Understand the complex regulation of phenomena of growth and flowering.
- Be able to use the knowledge gained to help crop growers, fruit farmers,floriculturists and others in the related area.

SYLLABUS OF DSC-12

Theory

Credits: 2 **Total Hours: 30**

Unit 1: Water relations **No. of hours: 9**

Water potential and its components (solute potential, pressure potential, gravimetric potentialand matric potential); inter cellular water transport (diffusion, mass flow and osmosis), short- distance transport (water absorption by roots), aquaporins, pathway of water movement (apoplastand symplast), water and ion uptake from soil into roots, root pressure, guttation, ascent of sap, cohesion-tension theory; Transpiration and its significance, factors affecting transpiration, anti- transpirants; Mechanism of stomatal movement (starch-sugar hypothesis, proton transport theory).

Unit 2: Plant Nutrition: uptake and distribution **No. of hours: 10**

Essential elements (macronutrients and micronutrients, criteria of essentiality, roles and deficiency symptoms), methods of study and use of nutrient solutions (ash analysis, hydroponics and aeroponics), Soil cation exchange capacity, transport of ions across cell membrane-passive transport and active transport, experimental evidence in support of phloem as the site of sugar translocation, Source-sink relationship, pressure flow model, phloem loading and unloading.

Unit 3: Regulation of plant growth **No. of hours: 5**

Discovery, basic structure, bioassays, physiological roles and commercial applications of auxins, gibberellins, cytokinins, abscisic acid and ethylene, general mechanism of mode of action of hormones. Brassinosteroids and Jasmonic acid (brief)

Unit 4. Physiology of Flowering **No. of hours: 6**

Photoperiodism: SDPs, LDPs, DNPs, photoinductive cycle(perception of photoperiodic signal), physiology of flowering (florigen concept), phytochrome (discovery, structure and responses on photomorphogenesis) vernalization, seed dormancy and germination (causes and methods to overcome dormancy).

2.1 Practical

Credit:2 **Total Hours: 60**

1. To determine the osmotic potential of plant cell sap by incipient plasmolytic method.
2. To determine the water potential by weight method.
3. To study the effect of two environmental factors on transpiration of an excised twig.
4. To calculate stomatal index and stomatal frequency of two surfaces of leaves of a mesophyte and a xerophyte.
5. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and a xerophyte (any one surface)
6. To demonstrate suction due to transpiration
7. To demonstrate the role of auxins in rooting of the cuttings
8. To study the phenomenon of Bolting
9. To study the role of Ethylene in fruit ripening
10. To study the effect of pH on anthocyanin pigments

Essential readings:

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons.U.S.A. 4th edition.
2. Kochhar, S.L. and Gujral, S.K. (2011). Comprehensive Practical Plant Physiology, Macmillan India Ltd, New Delhi.
3. Noggle, G.R. and Fritz,G.J. (1986).Introduction to Plant Physiology, 2nd Ed. PrenticeHall of India Ltd., New Delhi.
4. Salisbury, F.B. and Ross, C.W. (2005). Plant Physiology, Thomson Wadsworth, 4th edition.
5. Taiz, L., Zeiger, E. Moller, I.M. and Murphy, A. (2015). Plant Physiology and Development, Sinauer Associates Inc. U.S.A 6th edition.

Suggested readings:

1. Bhatla, S.C. and Lal M.A. (2018). Plant Physiology, Development and Metabolism, Springer Nature, 1st edition.
2. Nobel, P.S. (2009). Physicochemical and Environmental Plant Physiology, Academic Press, 4th edition.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Pool of DSE

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-4 :

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Natural resources and their Sustainable Utilization(BS-DSE-4)	4	2		2	Class XII pass with Biology and chemistry	NA

Learning Objectives:

Natural Resource Management (NRM) is an integrated and multidisciplinary approach combining Earth- Science, Life-Science, Environmental Science and Social Science to manage and restore natural resources andecosystems. This paper takes an objective view of the nature of Earth's resources, how and where they are generated, how they are extracted and used, and how these activities impact Earth's environment. It also addresses sustainability by looking into different ways of conservation of the natural resources and their management. Natural Resource Management helps to balance the needs of people and the economy with protecting the ability of ecosystems to support soil, water, forests, biodiversity, recreation and other resources

Learning Outcomes:

On successful completion of the course, a student will:

- Define and differentiate between biological and physical natural resources
- Appreciate the role of natural resources in ecological, economic and socio-cultural activities
- Understand the effect of anthropogenic interference on natural resources
- Understand the laws and policies associated with resource management and conservation

SYLLABUS for DSE-4

Course Contents – Theory

Unit 1: Natural Resources and Sustainable Utilization **No. of hours: 3**

Definition and types of Natural resources. Concept of sustainable utilization and approaches
(economic,ecological and socio-cultural), ecotourism

Unit 2: Land and Water **No. of hours: 6**

Land resources and land use patterns and changes: Land as a resource, land degradation, landslides (natural &man-induced), soil types of India, soil erosion and desertification.
Water resources (Fresh water (rivers, freshwater lakes, salt lakes, groundwater, aquifers, watershed); Marine; Estuarine), Use and over-exploitation of surface and ground water, floods, drought. Effects of climate change on water and land.

Unit 3: Biological Resources **No. of hours: 5**

Importance of Biological Resources in Human welfare. Threats; Management strategies; Bioprospecting;
IPR (Intellectual Property Rights); CBD (Convention on Biological Diversity); National Biodiversity
Action Plan,National Green Tribunal (NGT) and its role.

Unit 4: Forests and Energy **No. of hours: 8**

Forests & forest resources of India: Use and over-exploitation, Major and minor Forest products.
Energy resources: Renewable and non-renewable energy sources, use of alternate energy sources, impact ofgrowing energy needs and energy crisis- remedial measures.

Unit 5: Contemporary practices in Resource Management **No. of hours: 8**

Environment Impact Assessment (EIA), Geographical Information System (GIS), Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Types of waste andtheir management. National and international efforts in resource management and conservation

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Estimation of solid waste generated by a domestic system (biodegradable and non-biodegradable) andits impact on land degradation.
2. Collection of data on vegetation/ forest cover of specific city/state (any two) and correlate withconservation and socio economic practices.
3. Measurement of dominance of woody species by DBH (diameter at breast height) method.
4. Calculation and analysis of ecological footprint.
5. Estimation of soil organic carbon by Walkley and Black's method.
6. Ecological modeling.
7. Estimation of dissolved carbon-dioxide in different water samples.
8. Soil Analysis for water holding capacity, pore-space, cation-exchange capacity
9. Visit to landfill sites/ mining area/sewage treatment plant.

Essential Readings:

1. Craig, J.R., Vaughan, D.J. Skinner, B.J. (1996). Resources of the Earth: Origin, Use, and EnvironmentalImpact (2nd ed). Prentice Hall, New Jersey.
2. Klee, G.A. (1991). Conservation of Natural Resources. Prentice Hall Publ. Co., New Jersey
3. Owen, O.S, Chiras, D.D. and Reganold, J.P. (1998). Natural Resource Conservation – Management forSustainable future, (7thEdn.), Prentice Hall.
4. N. Vasudevan, Essentials of Environmental Science, Narosa Publishing House, (New Delhi), 2006
5. Vasudevan, N. (2006). Essentials of Environmental Science. New Delhi: Narosa Publishing House.
6. Sharma, P. D. (2017). Ecology and Environment. Meerut: Rastogi Publications

Additional Resources

1. J. S. Singh, S.P Singh and S. Gupta, Ecology, Environment and Resource Conservation, AnamayaPublications, (New Delhi), 2006

2. An P.P Rogers, K.F Jalal and J.A Boyd, Introduction to Sustainable Development, Prentice Hall of IndiaPrivate Limited (New Delhi), 2008

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-5 :

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Human Nutrition and Biochemistry (BS-DSE-5)	4	2		2	Class XII pass with Biology and chemistry	NA

Learning Objectives:

This course provides students with knowledge and understanding of the characteristics, function, metabolism and deficiency of macro and micronutrients in the human body. It involves integrated learning between the areas of Biochemistry and Nutrition.

Learning Outcomes:

On successful completion of the course, a student will:

- Critically analyze and evaluate concepts in nutritional biochemistry that are important for an understanding of human nutrition.
- Appreciate the biochemical underpinning of human nutrition in maintaining health.
- Demonstrate understanding of the biochemical basis of essentiality of macro and micronutrients and their nutritional deficiencies.
- Be aware of techniques used in the assessment of nutritional status and nutritional disorders.

Understand drug nutrient interactions

SYLLABUS FOR DSE-5

Course Contents -Theory

UNIT 1: Introduction to Nutrition and Energy Metabolism **No. of hours: 4**

Defining nutrition, role of nutrients. Unit of energy, Food energy, Specific Dynamic Action. Energy expenditure and its components, Energy Balance, Recommended Nutrient Intakes (RNI) and Daily Recommended Intakes for different age groups.

UNIT 2: Macronutrients **No. of hours: 10**

Food sources of carbohydrates, functions of carbohydrates, RDA, Factors affecting bioavailability, Glycemic index and glycemic load. Dietary fiber and the role of fiber in health. Role of Gut microbiome in maintaining health. Role of prebiotics and probiotics in nutritive health.
Essential Fatty Acids; Functions of EFA, AI, excess and deficiency of EFA, factors affecting bioavailability. Dietary implications of ratios of n6 and n3, MUFA, PUFA, SFA and Cholesterol in the body.
Functions of proteins in the body. RDA for different age groups. Essential and Nonessential amino acids. Complete and incomplete protein, Amino Acid Interactions: Antagonism, Toxicity, Imbalance, Amino acid complementation and Supplementation in foods. Protein quality determinants: Net protein utilization (NPU), Biological Value, Protein digestibility-corrected amino acid score (PDCAAS), Nitrogen balance. PEM: Marasmus and Kwashiorkor.

UNIT 3: Fat- and water-soluble Vitamins **No. of hours: 9**

Vitamin A, D, E, K and their dietary sources, RDA, Role of Vitamin A in Visual cycle and overview of other functions. Role of Vitamin K in Gamma carboxylation (blood clotting). Role of Vitamin E as an antioxidant. Role of Vitamin D in maintenance of bone physiology and overview of other functions. Vitamin C- Dietary sources, RDA, role in collagen synthesis. The B Complex vitamins- Dietary sources, RDA.Functions and role in metabolism, Role of Vitamin B12 and Folate in Hematopoiesis and Neurology Biochemical basis for deficiency symptoms, Hypervitaminosis.

UNIT 3: Minerals **No. of hours: 7**

Minerals: Dietary Sources, RDA. Sodium, Potassium, Calcium, Iron, Chloride, Copper and Phosphorus-Function, metabolism, Excretion, Deficiency and Toxicity.
Function, Metabolism, deficiency, Toxicity and Sources of Trace Elements: Iodine, Fluoride, Mg, Zn, Se,Chromium, Molybdenum.

PRACTICAL

CREDITS: 2 **TOTAL HOURS: 60**

1. Anthropometric identifications for nutrition related diseases –Body mass index (BMI), percentage body fat
2. Calculation of Basal Metabolic Rate (BMR) and Total daily Energy Expenditure (TDEE)
3. Determination of oxidative stress: Thiobarbaturic acid reactive substances (TBARS) in serum.
4. Assay of antioxidant enzymes in hemolysate/plant sources.
5. Estimation of vitamin A/E in serum.
6. Estimation of minerals in drugs/food/serum.
7. Determination of nutritive value of foods through Kjeldal's method, Soxhlet method
8. Understanding fortification and supplementation
9. Presentation and discussion on Food as medicine.
10. Group discussion on Nutrient-nutrient and drug-nutrient interactions
11. Case studies on nutritional disorders.

Essential Readings

1. Coombs Jr. G. F., (2008). *The vitamins, Fundamental aspects in Nutrition and Health.* Elsevier's Publications. ISBN-13- 978-0-12- 183493-7.
2. Mahan, L.K., Strings, S. E., Raymond, J. (2012) *Krause's Food and Nutrition Care process.* Elsevier's Publications. ISBN: 978-1-4377-2233-8.
3. Rosalind Gibson (2005). *Principles of Nutritional Assessment.* Oxford University Press. ISBN: 9780195171693
4. Tom Brody (1999). *Nutritional Biochemistry* (2nd Ed). Harcourt Braces. ISBN:9814033251, 978981403325
5. Malik, D., Narayanasamy, N., Vavilala, P., Takur, J., Sinha, N., (2022). Textbook of Nutritional Biochemistry. Springer Singapore, ISBN978-981-19-4149-8.

Suggested Reading

1. Devlin, T. M., (2011). *Textbook of Biochemistry with Clinical Correlations.* John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-6 :

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Conservation and Management of Wildlife (BS-DSE- 6)	4	2		2	Class XII pass with Biology and chemistry,	NA

Learning Objectives:

The Discipline Specific Paper on Wildlife Conservation and Management is designed to acquaint students with varied aspects of wildlife conservation, including its importance, major threats, management of their habitats and populations. The emphasis will be on developing interest and invoking a sense of responsibility among students towards wildlife conservation. The course also explores different techniques, perspectives, and approaches to both identify and achieve wildlife management goals. This course will motivate students to pursue career in the field of wildlife conservation and management.

Learning Outcomes:

Upon completion of the course, students will be able to:

- Understand the importance of wildlife in general, and its conservation and management in particular.
- Comprehend the application of the principles of ecology and animal behaviour to formulate strategiesfor the management of wildlife populations and their habitats.
- Understand the management practices required to achieve a healthy ecosystem for wildlife populationalong with emphasis on conservation and restoration.
- Know the key factors for loss of wildlife and important strategies for their in situ and ex situconservation.
- Recognize the techniques for estimation, remote sensing and Global Position Tracking for wildlife.
- Gain knowledge about the wildlife diseases and the quarantine policies.
- Know about the Protected Area Networks in India, Ecotourism, Ecology of perturbation and Climaxpersistence.
- Perform critical thinking, literature review; scientific writing as well as presentations; and participationin citizen science initiatives with reference to wildlife.

SYLLABUS for DSE-6
Course Contents- Theory

Unit 1: Introduction to Wildlife **No. of hours: 6**

Values of wildlife - positive and negative; Conservation ethics; Importance of conservation; Causes of depletion

Unit 2: Management of Habitats **No. of hours:4**

Setting back succession: Grazing logging; Mechanical treatment; Advancing the successional process:
Cover Construction

Unit 3: Wildlife identification and estimation **No. of hours: 8**

Fecal analysis of ungulates and carnivores: Faecal samples, slide preparation, and Hair
identification; Pugmarks and Census methods

Unit 4: Wildlife Health Management **No. of hours: 6**

Common diseases of wild animals: Zoonosis (Ebola and Salmonellosis), Rabies, Foot and Mouth
Disease,Mycobacterium TB, Bovine and Avian Flu

Unit 5: Protected Areas and Management **No. of hours: 6**

National parks and sanctuaries; Biosphere reserves; Conservation and Community reserve; Important

features of protected areas in India; Tiger conservation - Tiger reserves in India and management

challenges in Tiger reserves. Human-wildlife conflict; Ecotourism / wild life tourism in forests

PRACTICAL

Credits: 2 **Total Hours: 60**

1. Identification of mammalian fauna, avian fauna, herpeto-fauna through direct and indirect evidencesseen on a field trip to a wildlife conservation site.
2. Demonstration of basic equipment needed in wildlife studies use, care and maintenance (Compass,Binoculars, Spotting scope, Range Finders, Various types of Cameras and lenses).
3. Familiarization and study of animal evidences in the field: Identification of animals through Pug marks,Scats & Nests.
4. Identification of big cats: Lion, Tiger, Cheetah, Leopard and Jaguar.
5. To Study the various Animal tracking systems: VHF, UHF, GPS and GIS
6. Trail / transect monitoring for abundance and diversity estimation of wildlife (direct and indirectwildlife evidences).

7. A report based on a visit to National Park/Wildlife Sanctuary or any other wildlife conservation site.

Essential Readings

1. Saha, G.K. and Mazumdar, S. (2017) Wildlife Biology: An Indian Perspective. PHI learning Pvt. Ltd.ISBN: 8120353137, 978-812035313
2. Sinclair, A.R.E., Fryxell, J.M. and Caughley, G. (2006) Wildlife Ecology, Conservation andManagement. Wiley-Blackwell, Oxford, UK.
3. Singh, S.K. (2005) Text Book of Wildlife Management. IBDC, Lucknow.
4. Hossetti, B. B. (1997). Concepts in Wildlife Management. Daya Publishing House, Delhi.

Suggested Readings:

1. Hudson, P.J., Rizzoli, A., Grenfell, B.T. Heestrbeek, H. and Dobson, A.P. (2002) The Ecology of Wildlife Diseases. Oxford University Press, Oxford.
2. Banerjee, K. (2002) Biodiversity Conservation in Managed and Protected Areas. Agrobios, India. • Sharma, B.D. (1999) Indian Wildlife Resources Ecology and Development. Daya Publishing House, Delhi.
3. Primack, R.B. (1998). Essentials of Conservation Biology. Sinauer Associates, Inc. Sunderland, MA.

Online Tools and Web Resources:

- https://swayam.gov.in/courses/4687-july-2018-wildlife-conservation
- https://swayam.gov.in/courses/5364-jan-2019-wild-life-ecology
- https://papaco.org/mooc-on-species-conservation/
- https://www.iucn.org/theme/protected-areas/our-work/capacity-development/moocs
- https://www.zsl.org/united-for-wildlife-free-conservation-courses
- https://wildlife.org/next-generation/career-development/online-courses/
- https://www.openlearning.com/umtmooc/courses/wildlife-management

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY THE DEPARTMENTS

GRNERIC ELECTIVE COURSE –GE-1 :

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Light and Life (BS-GE- 1)	4	2		2	Class XII pass with Biology and chemistry,	NA

Course Objective:

The course explores the physical properties of light and its interplay with living organisms. Light as a source of energy and information has shaped life on earth over the last 3.6 billion years. We see the world around us because the light reflected to the retina is processed to our brain (Photoreception), we breathe in oxygen because it has been evolved by the plants around us due to the light dependent Photosynthesis. Where there is no natural light organisms produce their own (Bioluminescence). Maintaining coordination with the surrounding light regime is fundamentally important to the inherent biological clock in organisms which needs re-calibration almost every 24 hours (Circadian Rhythms); whereas a disruption may lead to adverse effects. Every part of the spectrum is used in one way or the other by different life forms. In this paper students will be able to appreciate the delicate processes of life that are dependent on light.

Course Learning Outcomes:

- Students will understand and appreciate the dual nature of light.
- Students will comprehend the impact of light on biodiversity from pole to pole.
- Students will gain knowledge about the various photoreceptors in plants and animals and will appreciate and understand the mechanism of photosynthesis.
- Students will understand bioluminescence, photoperiodism and biological rhythms.
- Students will gain knowledge about the ecological and physiological responses to light.

Syllabus for GE-1

THEORY
TOTAL HOURS: 30 CREDITS: 2

Unit I: Introduction to Light and Life **No. of Hours: 4**

Nature of light (Wave and Particle), spectrum of light. Measurement of light (Lux, Candela, Foot Candle). Polarized light, light attenuation in water. Light as an ecological factor affecting distribution of plants and animals (Phyto and Zoo geography), in terrestrial and aquatic ecosystems. Latitudinal Diversity gradient.

Unit II: Photoreception **No. of Hours: 4**

Comparative account of chemistry and functional roles of pigments associated with harvesting light energy: photoreceptors in plants: chlorophylls, carotenoids, phycobilinoproteins, bacteriochlorophylls etc. Photoreception in animals, color vision and visual processing in human eye.

Unit III: Photosynthesis **No. of Hours:6**

History, Structure of chloroplast, Photosynthetic equation, Photosynthetic electron transport (cyclic and non-cyclic), photolysis of water, , concept of Reaction centers, , Dark Reactions in Photosynthesis, C3, C4, CAM cycle, Regulation of PCR cycle, photorespiration (C2 cycle), photoautotroph vs. photoheterotrophs; Photoautotroph vs. chemoautotroph, Anoxygenic and oxygenic photosynthesis.

Unit IV: Bioluminescence **No. of Hours: 6**

Definition, discovery, diversity of organisms, Functions and mechanism of Bioluminescence (*Photinus pyralis, Aequorea victoria*).

Unit V: Photoperiodism **No. of Hours: 10**

Photoperiodism: phytochromes, LDP, SDP, DNP plants, vernalization, vernalin, etiolation and de-etiolation. Animal responses to changing photoperiodism. Physiological and Behavioural adaptations to extreme light conditions in plants and animals. Three rhythm domains, Biological clock and Circadian rhythms. Sleep disorders, Shift work disorder, Jetlag.

Unit VI: Ecological and physiological responses to Light **No. of Hours: 6**

Color in animals: chromatophores and colour changes in animals, morphological and physiological colour change. Role of Light as an inducer for biosynthesis of Vitamin D and Melatonin along with significance .Thymine dimer formation, skin cancer and cataract in response to UV exposure. Light pollution and its impacts on environment, ecosystems and wildlife.

PRACTICALS

TOTAL HOURS: 60 CREDITS: 2

1. To study light penetration in water using Secchi disc.
2. To demonstrate the effect of light on soil fauna using Berlese funnel setup.
3. To study the effect of light and darkness on the chromatophores of fish.
4. To test / survey for color blindness using Ishihara charts.
5. To study oxygen liberation during photosynthesis using Hydrilla. Measurement of light using Luxmeter.
6. Separation of Chloroplast pigments by Paper Chromatography.
7. Demonstration of Hills Reaction and study the effect of Light intensity (any 2 light conditions).
8. To study the effect of Light intensity and CO2 concentration on the rate of photosynthesis

Essential Readings:

1. Björn, L. O. (2015) 3rd Ed. *Photobiology: Science of Light and Life*, L.O. Bjorn.,Springer
2. Buchanan, B. B., Gruissem, W., and Jones, R. L. (2000). *Biochemistry and molecularbiology of plants.* Rockville, Md.: American Society of Plant Physiologists.
3. Huner, N. and Hopkins, W. (2013). *Introduction to Plant Physiology.* In: 4th ed. JohnWiley & Sons, Inc.
4. Kohen E., Santus R., Hirschberg J.G. (1995) 1st Ed., *Photobiology* Academic Press
5. Randall D., Burggren W., & French k. (2001) 5th Ed. *Eckert, Animal PhysiologyMechanisms*
6. *and Adaptations.* W.H. Freeman and Co.

Suggested Readings:

1. Gross M. (2003). *Light and Life*. Oxford University Press
2. Shimomura O., (2012) *Bioluminescence: Chemical Principles and Methods*, World Scientific,
3. Taiz, L., &Zeiger, E. (1991).*Plant physiology*. Redwood City, Calif:Benjamin/Cummings Pub. Co.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GRNERIC ELECTIVE COURSE –GE-2 :

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Wellness and health (BS-GE- 2)	**4**	**2**		**2**	Class XII pass	**NA**

Learning Objectives

This course aims at creating consciousness among the students towards health, fitness and wellness and in developing and maintaining a healthy life style. The course provides an introduction to basic personal health issues and concerns in today's society. The course will lay emphasis on current health issues such as malnutrition, mental health, sleep hygiene, substance abuse and stress. Upon completion, students should be able to demonstrate an understanding of the factors necessary to lead a stress free and healthy life.

Learning Outcome

Upon successful completion of this course, the student will be able to:

1. Define Health and Wellness and understand the importance of a healthy lifestyle
2. Be familiar with factors contributing to physiological and mental health
3. Discuss misconceptions about nutrition and weight management; appreciate factors that contribute to malnutrition.
4. To create awareness of various life style related diseases and maintain a reasonable and cardiac-respiratory fitness and health.
5. Understand factors that contribute to stress, identify stressors commonly reported by different groups and appreciate ways to manage stress.
6. Identify the characteristics of emotionally and mentally healthy individuals
7. Identify the characteristics and risk factors of sexually transmitted infections and disease

GE-2 Syllabus

THEORY

Credits:2 **Total hours: 30**

UNIT I: Understanding Wellness and Health **2 hrs.**

Defining health, Factors that contribute to health and wellness: Genetic, Physiological, Physical, Psychological, Social and Geopolitical.

UNIT II: Nutrition and Health **6 hrs.**

Definition of Nutrition, Understanding different body types in relation to appropriate diet, Concept of Balanced Diet, Diet Plans: Keto diet, Intermittent fasting, Paleo diet, Atkins diet; Malnutrition and its contribution to ill health. Current concerns in India regarding Nutrition and Health.

UNIT III: Sleep, Mental Health and Stress **6 hrs**

Defining sleep, Sleep Physiology and sleep wake cycle, Stages of sleep, Sleep hygiene and its contribution to health, Basic physiology of stress and mental health, Psychosomatic illness, PTSD, Depression and Anxiety; Social, Psychological, Physiological and Environmental factors contributing to stress and its mental health

UNIT IV: Lifestyle Management and Fitness 6 **hrs**

Understanding Non-Communicable diseases (NCD), Cardiovascular and pulmonary health and disease, Diabetes Mellitus and Obesity. Management of Life Style disease: Diet, sleep, exercise and stress management. Cardiopulmonary fitness, Maintenance of Healthy lifestyle, Exercise: types, benefits; Yoga and Pranayama.

UNIT V: Addiction and Health Concerns **5 hrs**

Definition of Addiction, Physiology and psychology of addictive behaviour, Addiction of alcohol, drugs, nicotine and electronic devices and their effect on health, Deaddiction, Counselling and Rehabilitation

UNIT VI: Sexual Health and Disease **5 hrs**

Overview of reproductive physiology, Contraception, sexually transmitted disease (HIV, Herpes, Cervical cancer), PCOS, Infertility and health

PRACTICALS

Credits: 2 **Total hours: 60**

1. Calculating BMI, BMR and Total daily energy expenditure
2. Calculating Nutrient Intake and Total Daily Energy Intake
3. Calculating Energy balance and obesity indices like percent body fat, Body Conicity Index and Body Adiposity Index, Waist to Hip ratio
4. Measuring Blood Pressure and Pulmonary function tests.
5. Determining Mental Health through established questionnaire.
6. Maintaining record and calculating sleep hours.
7. Case Studies: Life Style Disorders, Sexually Transmitted Diseases

ESSENTIAL READINGS:

1. Physical Activity and Health by Claude Bouchard, Steven N. Blair, William L. Haskell. ISBN-13: 978-0736095419

2. Mental Health Workbook by Emily Attached & Marzia Fernandez, 2021. ISBN-13:979-8640649550
3. Lifestyle Diseases: Lifestyle Disease Management, by C. Nyambichu & Jeff Lumiri, 2018.
4. An Invitation to Health 18th ed., by Dianne Hales ISBN: 1337392898
5. The Psychology of Addiction by Jenny Svanberg, 2018 ISBN-13: 978-1133104544
6. Introduction to Human Physiology by Lauralee Sherwood, ISBN-13:978-1133104544

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER-V

Category I

(BSc Honors in Biological Science in three years)

DISCIPLINE SPECIFIC CORE COURSE – 13:

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Molecular Biology I(BS-501)	4	2		2	Class-XII pass with Biology & Chemistry	Should have a background in chemistry of biomolecules and enzymes

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce to the students, the basic concepts of genome, DNA structure, genes, chromatin and chromosomes.
- Provide an understanding of mechanism of DNA replication, recombination, mutations and repair.
- Teo enable students to apply this knowledge in understanding the life processes and develop an interest to pursue high quality research.

Learning outcomes

On successful completion of the course, students will be able to:

- Explain the basic information about the structure of DNA and various forms of DNA, about organization of genome in various life forms, supercoiling of DNA and its significance
- Outline and elaborate the molecular basis of processes like DNA replication, recombination and transposition and explain the significance of these processes
- Discuss about the various ways in which the DNA can be damaged leading to mutations and lesions and the different ways that DNA damage can be repaired.

SYLLABUS FOR DSC-13

Credits: 2 **Total hours: 30**

UNIT 1: Structure of DNA and genomic organization **No. of hours: 8**

Watson and Crick model of DNA, various forms of DNA, Supercoiling of DNA, linking number, Topoisomerases, Topoisomerase inhibitors and their clinical importance, Definition of a gene, organization of genes in viruses, bacteria and eukaryotes, concept of split genes, introns, exons, satellite DNA, highly repetitive DNA.

UNIT 2: Replication of DNA **No. of hours: 10**

The chemistry of DNA synthesis, DNA polymerase, the replication fork, enzymes and proteins in DNA replication, *E coli* DNA polymerases, stages of replication: initiation, elongation, origin of replication, relationship between replication and cell division, replication in eukaryotes, end replication problem, telomerases. Comparison of replication in prokaryotes and eukaryotes.Inhibitors of DNA replication and applications in medicine.

UNIT 3: Recombination and transposition of DNA **No. of hours: 6**

Homologous recombination, enzymes in homologous recombination, site-specificrecombination, recombinases. Transposition, DNA transposition by cut and paste and replicativemechanism.

UNIT 4: Mutations and DNA Repair **No. of hours: 6**

Types of mutations, DNA damage by hydrolysis, alkylation, oxidation and radiation. Mutations caused by base analogs and intercalating agents. Ames test. Replication errors and their repair, mismatch repair system, repair of DNA damage-direct reversal of DNA damage, base excision repair, nucleotide excision repair, translesion DNA synthesis. DNA repair diseases.

PRACTICALS
CREDITS: 2 **TOTAL HOURS : 60**

1. DNA estimation by DPA
2. Separation of nitrogenous bases by paper chromatography
3. To plot the ultraviolet absorption spectrum of DNA
4. Isolation of chromosomal DNA from *E coli* cells
5. Determination of DNA concentration and purity by UV absorption.
6. Determination of the melting temperature of DNA
7. Demonstration of the mechanism of Transposition and Recombination (Dry Lab)

ESSENTIAL READINGS

1. Lehninger: Principles of Biochemistry (7th ed.) (2017) Nelson, D.L. and Cox, M.M W.H.Freeman & Company (New York), ISBN:13: 9781464126116 / ISBN:10-1464126119.
2. Molecular biology of the gene: (7th ed), (2014) Watson, J. D., Baker, T. A., Bell, S. P.,Gann, A., Levine, M., & Losick, R. International). Pearson.

SUGGESTED READINGS

1. Genetics - A Conceptual Approach,) (6th ed). (2012), Pierce, B.A. W.H. Freeman & Co.(New York), ISBN:13:978-1-4292-7606-1 / ISBN:10:1-4292-7606-
2. Lewin's Gene X (10th edition) (2018). Lewin, B., Krebs, J.E., Kilpatrick, S.T., Goldstein,E.S., Bartlett Learning publishers, LLC, ISBN: 978-0-7637-6632-0.
3. The Cell: A Molecular Approach (7th ed.) (2009). Cooper, G.M. and Hausman, R.E. ASMPress & Sunderland (Washington DC), Sinauer Associates, MA. ISBN:978-0- 87893-3030.
4. *Biochemistry* (6th ed.) (2016). Garrett, R. H., & Grisham, C. M. Brooks Cole. ISBN:9781305882409

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, Universityof Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 14

Credit distribution, Eligibility and Pre-requisites of the Course

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Transmission and Molecular Genetics (BS-DSC-502)	4	2		2	Class XII pass with Biology and chemistry.	

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide the students with an understanding of both classical and modern concepts in genetics.

- To familiarize them with the principles and mechanisms of the inheritance of traits and genes, various modes of inheritanceof traits/ phenotypes and Phenotype-genotype correlation.
- To understand the areas of transmission genetics, different mapping techniques, chromosomal aberrations andmolecular and developmental genetics.
- To corelate practical exercises with the theory and facilitate skill-oriented learning outcomes

Learning outcomes

Upon completion of the course, the students will be able to:

- Understand the concept of genotype and phenotype, describe the basic principles of Mendelian genetics and appreciate the various factors that confer genotypic and phenotypicvariability.
- Understand the inter relationship between environment (Nurture) versus inheritance(Nature) in determining the conversion of genotype to phenotype.
- Be able to use the concepts of bacterial and viral genetics to understand resistance patternsand to create linkage and genetic maps
- Be able to apply the principles of transmission and inheritance in real life situations.

SYLLABUS OF DSC- 14

Theory

TOTAL HOURS: 30 **CREDITS: 2**

Unit 1: Transmission Genetics **No. of hours: 8**

Introduction to the basic principles of heredity. Mendelian Genetics and Extensions: Mendel'swork on transmission of traits, genetic variation, molecular basis of Genetic Information.

Principles of Inheritance, Chromosome theory of inheritance, Laws of probability, Incompletedominance and codominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy Penetranceand expressivity, norm of reaction and phenocopy. Polygenic inheritance; continuous and discontinuous variation.

Unit 2: Organelle heredity and Chromosomal variations **No. of hours: 6**

Chloroplast mutation/variegation in four'o'clock plant, mitochondrial mutations in Neurospora, maternal effects, infective heredity- Kappa particles in Paramecium. Chromosomal aberrations: Variations in chromosome number and structure.

Unit 3: Linkage, crossing over and mapping techniques **No. of hours: 4**

Linkage and Crossing over, cytological basis of crossing over, Molecular mechanism of crossingover. Recombination frequency as a measure of linkage intensity, two factor and three factor crosses, Interference and Coincidence

Unit 4: Molecular genetics **No. of hours: 6**

Sex determination: Genetic basis of sex determination in Humans, *Drosophila melanogaster,* sexlinked, sex influenced and sex limited traits. Mechanism of dosage compensation- X chromosome inactivation.Epigenetic mechanisms of transcriptional regulation, Genomic imprinting. Eukaryotictransposable elements- Ac-Ds system in maize and P-elements in drosophila.

Unit 5: Genetics of bacteria and virus **No. of hours: 6**

Complementation test, limitations of cis-trans test, intragenic complementation, rII locus of phage T4 and concept of cistron. Mechanism of genetic exchange - conjugation, transformation and transduction. Prokaryotic transposable elements- IS elements, Composite transposons, Tn-3 elements.

Practical

Credits: 2 **Total Hours: 60**

1. To understand the genetic interaction involved using the seed mixture given (all six ratios)
2. Study of Linkage, recombination, gene mapping using marker-based data from Drosophila.
3. Preparation of karyotype and idiogram from the metaphasic plate of *Phlox/Allium sp*
4. Effect of colchicine and demonstration of polyploidy in *Allium sp.*
5. PTC testing in a population and calculation of allele and genotype frequencies.
6. Study of abnormal human karyotype.
7. Study of pedigree conventions and pedigree analysis
8. Squash preparation of salivary glands of Dipteran larva to observe polytene chromosomes.
9. Smear technique to demonstrate sex chromatin in buccal epithelial cells.

Essential readings:

1. Griffiths, A. J. F., Wessler, S. R, Carroll, S. B., Doebley, J. (2010). An Introduction to Genetic Analysis (10thed.). W.H. Freeman & Company (New York). ISBN:10: 1- 4292-2943-8
2. Pierce, B.A. (2012). Genetics - A Conceptual Approach (4thed.). W.H. Freeman & Co. (New York). ISBN:13: 978-1-4292-7606-1 / ISBN: 10:1-4292-7606-1
3. Snustad, D. P., Simmons, M. J. (2015). Principles of Genetics (7th ed.). ISBN: 978-1-119-14228-7.
4. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, 8th edition. New Delhi, Delhi: John Wiley & sons.
5. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics, 10th edition. San Francisco, California: Benjamin Cummings.

Additional Readings:

a. Raven, F.H., Evert, R. F., Eichhorn, S.E. (1992). Biology of Plants. New York, NY: W.H. Freeman and Co. Additional Resources
b. Hartl, D.L., Ruvolo, M. (2012). Genetics: Analysis of Genes and Genomes, 8th edition.New Delhi, Delhi: Jones and Bartlett Learning.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch,University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE –15 :

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Growth and Reproduction (BS-DSC-503)	4	2		2	Class XII pass with Biology and chemistry	**Understanding of animal and plant physiology**

Learning Objectives

The Learning Objectives of this course are as follows:

- To allow students to explore the development of plants and animals from juvenile to mature phase.
- To enthuse students to explore the myriad ways in which plants produce fruits and seeds, and encourage them to pursue further studies in plant reproductive biology and its genetic regulation.
- To explore the fundamentals of reproduction anddevelopment in animals particularly vertebrates, from fertilization to organogenesis, primarily for understanding of tissue differentiation and molecular mechanisms fundamental to developmentof animals.

Learning outcomes

By the end of the course, the student will be able to:

- Students will understand the development of plants from juvenile to senescent stage with the associated genetic, cellular, anatomical and morphological changes.
- Students will appreciate the role of pollinators and get hands-on experience of observing patterns on pollen grains, pollen germination, embryo and endosperm dissection, and collecting seeds with different dispersal mechanisms.
- Students will understand the reproductive system in animals and human beings so as to relate with the control of population and environmental threats in the current scenario.
- Students will be able to explain how errors in development can lead to congenital defects.
- Students will visualize and appreciate concepts learnt in theory and apply experimental approaches to understand these developmental events in the laboratory

SYLLABUS OF DSC-15

Theory

Credits: 2 **Total Hours: 30**

Unit 1: Introduction to Growth and Reproduction **No. of hours: 5**

Vegetative and Reproductive phases of growth in plants, senescence and abscission. Functional anatomy of male and female reproductive systems in humans.

Unit 2: Fertilization **No. of hours: 10**

Sexual reproduction in angiosperms: Structure and organisation of flower, organization of typical tetrasporangiate anther and eight nucleate embryo sac (Polygonum type), pre-fertilization events in plants, microgametogenesis and megagametogenesis, anther dehiscence, pollination, pollen- pistil interaction, pollen germination, double fertilization.

Gametogenesis- Spermatogenesis and Oogenesis with reference to human, Estrus and menstrual cycle, Types of eggs in animals, capacitation, fertilization and development of an embryo from zygote, Causes of Infertility.

Unit 3: Embryogenesis in Plants and Animals **No. of hours: 10**

Post fertilization events in plants: Types of embryogenesis (with special emphasis on dicot embryogenesis), endosperm development, types of endosperm, seed formation, seed dispersal: mechanisms and agents. Embryogenesis; Types of cleavages, Morphogenetic movements, Gastrulation in humans; Extra Embryonic membranes, Mechanism of Implantation, Placentation: Endocrine functions and types based on chorionic villi distribution and histology. feto-placental unit

Unit 4: Differentiation **No. of hours: 5**

Post-embryonic meristem in plants with special reference to *Arabidopsis* embryogenesis. Role ofmeristem in differentiation, shoot and root apical meristems, lateral meristem (vascular and cork cambium), floral meristem, ABC model of flowering. senescence and abscission

Formation of organs Organogenisis during development, critical windows of development in humans during pregnancy. Teratogens and Ageing.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Luteinizing Hormone (LH) Levels and HCG based test.
2. Vaginal smear preparation to examine estrous cycle.
3. Preparation and histological study of mammalian testis and ovary or Examination of histological sections from photomicrographs/ permanent slides of rat/human: testis, epididymis and accessory glands of male reproductive systems; Sectionsof ovary, fallopian tube, uterus (proliferative and secretory stages), cervix and vagina; Study different types of mammalian placenta on the basis of histology andmorphology.

4. Case studies on teratogens.
5. Study different stages of micro and mega-gametogenesis in angiosperms-throughpermanent slides.
6. To study percent pollen germination using different media.
7. To study embryo development in flowering plant /slides.
8. To dissect out endosperm and embryo from angiosperm seeds.
9. Study of apical and lateral meristem by permanent slides.
10. Survey of dispersal mechanisms of seeds/ pollination agents
11. To study Polyembryony/ Types of Embyo sacs through permanent slides/ photographs/temporary prepartions/chart
12. Project report on visit to animal house facility/ IVF lab.

Essential Readings:

1. Bhatnagar, S. P., Dantu, P. K., & Bhojwani, S. S. (2018). The Embryology of Angiosperms, 6th Edition.Vikas
2. Raghavan, V. (2000).Developmental Biology of Flowering Plants.New York: Springer.
3. Tortora, G. J., & Derrickson, B. (2017). *Principles of anatomy & physiology*. Fifteenth edition; Wiley Loose-Leaf Print Companion. Hoboken, New Jersey: John Wiley & Sons, Inc.
4. Regulation of Implantation and Establishment of Pregnancy in Mammals, Editors: Rodney D Geisert, Fuller W. Bazer, ISBN 978-3-319-15856-3, Springer International Publishing, 2015.
5. Gilbert, S. F., & Barresi, M. J. F. (2016).

Developmental biology.

Additional readings:

1. Kalthoff, K. O. (2000). Analysis of Biological Development (2 edition). Boston: McGraw-Hill Science/Engineering/Math.
2. William. J. Larsen.(2001). Human Embryology (3 edition). New York: Churchill Livingstone.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch,University of Delhi, from time to time.

Pool of DSE

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-7 :

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant resource Utilization (DSE-7)	4	2		2	Class XII pass with Biology and chemistry, as one of the papers in Class XII	NA

Learning Objectives:

- To make the students familiar with the economic importance of diverse plants that offer resources to human life.
- It emphasizes the plants used as- food for man, fodder for cattle, feed for poultry, plants having medicinalvalue and also plant source of huge economic value etc.
- After studying Economic Botany, students would havefirst-hand information of plants used as food and the various kinds of nutrients available in the plants. The dietary requirements of proteins, fats, amino-acids, vitamins etc that can be met by plants.
- They will also learn about the use of fibre plants, beverages, oil yielding and medicinal plants that are integral to day to day life .

Learning Outcomes:

On successful completion of the course, a student will:

- Know about the concept of origin of cultivated plants
- Gain an understanding of morphology, processing and economic value of plant sources of cereals,legumes, spices, oil, beverages, medicines etc.
- Gain an insight into the importance of medicinal plants and their therapeutic properties
- Understand the extraction of essential oils and their commercial applications.
- Learn to perform the micro-chemical tests to demonstrate various components present ineconomically important plants.

SYLLABUS FOR DSE-7

Course Contents - Theory

UNIT 1: Origin of Cultivated Plants **No. of hours: 3**

Cultivated Plants: origin and importance with particular reference to the works of A. de Candolle and Vavilov(especially centers of diversity, primary and secondary centers). Major plant introductions.

UNIT 2: Cereals and Legumes **No. of hours: 6**

Cereals- General account and Importance of cereals with special reference to Wheat (origin, evolution, morphology & uses); Legumes- General account, Importance of legumes to man and ecosystem with specialreference to Gram and Soybean (origin, morphology & uses).

UNIT 3: Spices and Beverages **No. of hours: 8**

Spices: General account with special reference to clove, turmeric and black pepper (Botanical name, family,part used, morphology and uses)
Beverages: General account with special reference to non-alcoholic beverages. Tea (morphology, processing,uses)

UNIT 4: Oils and Fats (Edible,Non-edible and Essential) **No. of hours: 6**

General description and classification;extraction of Edible and essential oils; uses and health implications; Groundnut, Mustard (Botanical name, family, morphology of the part used & uses). Adulteration of edible oils.Dropsy disease.

UNIT 5: Drug Yielding Plants **No. of hours: 4**

Therapeutic and habit-forming drugs with special reference to *Cinchona, Digitalis, Papaver* and *Cannabis*.

UNIT 6: Fibres **No. of hours: 3**

Classification based on the origin of fibres; Cotton (origin of tetraploid cotton, morphology, processing anduses).

PRACTICAL

Credits: 2 **Total Hours: 60**

1. Cereals: Wheat (habit sketch, L.S/T.S. grain, micro-chemical tests)
2. Legumes: Soybean, Groundnut (habit sketch, fruit, seed structure, micro-chemical tests).
3. Spices: Black pepper, Fennel and Clove (habit sketch and sections L.S./T.S.).

4. Beverages: Tea (plant specimen, sectioning of tea leaves) Coffee(Plant specimen and fruits)
5. Oils and fats: Groundnut- plant specimen, habit sketch, micro-chemical tests
6. Drug-yielding plants: Specimens of *Cinchona, Digitalis, Papaver* and *Cannabis*.
7. Fiber-yielding plants: Cotton (specimen, whole mount of fiber and micro-chemical test),jute (specimen, whole mount of fibre and micro-chemical test)
8. Essential oil-yielding plants: Habit sketch of *Rosa, Vetiveria, Santalum* and *Eucalyptus* (specimens/photographs).
9. Dye yielding plants: Any two (*Indigofera*/*Henna*/*Bixa/Butea*)
10. Report on study of Industrially important plants (specimens/products)- morphology, botany and uses.

3.1 Essential readings:

1. Kochhar, S.L. (2012). *Economic Botany in Tropics*. New Delhi, India: MacMillan & Co.
2. Wickens, G.E. (2001). *Economic Botany: Principles & Practices*.The Netherlands: Kluwer AcademicPublishers.

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-8

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Membrane Biology (BS-DSE-8)	4	2		2	Class XII pass with Biology and chemistry	**Basic cell biology**

Learning Objectives:

The objective of the course is to provide students with

- The basic understanding of membrane composition, structure-function relationship, and properties of membranes.
- To provide an understanding of the various types of membrane transporters and their molecular mechanisms.
- Provides an understanding of molecular mechanisms involved in vesicular transport processes and membrane fusion.

Learning Outcomes:

On successful completion of the course, a student will:

- Understand the general composition and structure of biomembranes.
- Gain knowledge of the basic properties of membranes such as membrane fluidity.
- Have knowledge about the various types of membrane transport mechanisms.
- Have knowledge about the molecular mechanism of vesicular transport and membrane fusion.

SYLLABUS FOR DSE-8

Course Contents -Theory

UNIT 1: Membrane composition and structure **No. of hours: 8**

Composition of membranes: Lipids (Phospholipids, Glycolipids, sterols), Proteins (Peripheral Proteins, Integral Membrane Proteins and Lipid-Anchored proteins) and carbohydrates. Historical background and various membrane models. Comparison of various cellular and subcellular membranes. Lateral and transverse asymmetry in membranes. Role of Flippase, Floppase and Scramblase. Model systems to study membranes- Lipid monolayers, Planar bilayer, Liposome and their applications. Polymorphic Lipid-Water Systems. Determinants of polymorphic phases: Critical Micellar Concentration (CMC), lipid shape, critical packing parameter.

UNIT 2: Membrane dynamics **No. of hours: 6**

Membrane fluidity: lateral, transverse and rotational motion of lipids and proteins. Factors affecting membranefluidity- composition, barriers (tight junctions), cytoskeleton interactions,
Microdomains- rafts, caveolae. Study of RBC membrane architecture. Homeoviscous adaptation. Techniquesto study membrane dynamics: FRAP, TNBS, SPT.

UNIT 3: Membrane transport **No. of hours: 10**

Thermodynamics of transport. Simple diffusion and facilitated diffusion. Passive transport glucose transporterand anion transporter. Primary active transporters- P-type ATPases, V-type ATPases, F-type ATPases. Secondary active transporters- Lactose permease, Na^+-glucose symporter. ABC family of transporters- MDR and CFTR. Group translocation (PEP-PTS) and bacteriorhodopsin. Ion channels: voltage-gated ion channels (Na^+ and K^+ channel) and ligand-gated ion channels (Acetylcholine receptor) and aquaporins. Ionophores: valinomycin, gramicidin. Relationship between membrane transport and diseases.

UNIT 4: Vesicular transport and membrane fusion **No. of hours: 6**

Vesicular transport. Vesicles, Clathrin-coated Vesicles and COP-Coated Vesicles (COPI and COPII).

Molecular mechanism of vesicular transport. Membrane fusion (dynamin protein, Rab proteins, NSF/ SNAP
complex, SNARE proteins). Receptor Mediated Endocytosis: LDL and Transferrin.

PRACTICALS

CREDIT: 2 **TOTAL HOURS: 60**

1. Effect of lipid composition on the permeability of a lipid monolayer.
2. Isolation of membrane phospholipids and separation by TLC.
3. Effect of temperature, pH, detergents and ionic strength on Tonoplast membrane of beetroot.
4. Determination of CMC of Neutral and Ionic detergents.

5. Preparation of RBC ghost cell.
6. Separation of RBC membrane proteins by SDS-PAGE.
7. Demonstration of Histidine uptake from the intestinal membrane.

Essential readings:

1. Garret, R.H., Grisham, C.M. (2016). Biochemistry (6th ed.). Boston, Cengage Learning. ISBN-10: 1305577205, ISBN-13: 978-1305577205
2. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Martin, K.C., Yaffe, M., Amon, A. (2021). Molecular Cell Biology (9th ed.). New York, WH: Freeman & Company. ISBN-13:978-1319208523, ISBN-10:1319208525.
3. Nelson, D.L., Cox, M.M. (2021). Lehninger: Principles of Biochemistry (8th ed.). New York, WH: Freeman and Company. ISBN: 13: 978-1319381493 / ISBN-10:1319381499.
4. Voet, D., Voet. J. G. (2013). Biochemistry (4th ed.). New Jersey, John Wiley & Sons Asia Pvt. Ltd. ISBN: 978-1-11809244-6.
5. Wardhan, R., Mudgal, P. (2017). Textbook on Membrane Biology (1st ed.). Singapore, Springer. ISBN-10: 9811071004, ISBN-13: 978-9811071003

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-9 :

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Ethology (BS-DSE-9)	4	2		2	Class XII pass with Biology and chemistry,	NA

Learning Objectives:

Ethology or Animal Behavior is the scientific study of the wild and wonderful ways in which animals interact with each other, with other living beings, and with the environment in which they live in. One important aspect pertaining to the studies on Animal Behavior is that it can be conducted anywhere and at any time, depending on the interest of the researcher. Moreover, it is not confined to the four walls of the classroom or the laboratory. Thebehavioral biology has high applied value and currently linked to conservation biology, molecular biology, behavioral ecology and integrated pest management. This course will help the learners to understand and appreciate different types of animal behaviors, their adaptive, evolutionary and practical significance.

Learning Outcomes:

Upon completion of the course, students will be able to:

- Understand types of animal behaviour and their importance to the organisms.
- enhance their observation, analysis, interpretation and documentation skills by taking short projectspertaining to Animal behaviour and emotions.
- Relate animal behaviour with other subjects such as Animal biodiversity, Evolutionary biology, Ecology,Conservation biology and Genetic basis of the behaviour.
- Realize, appreciate and develop passion to biodiversity; and will respect the nature
- Learn to evaluate and analyse human behaviour and emotions, and develop intuitive skills and empathyfor better leadership qualities

SYLLABUS FOR DSE -9

Course Contents- Theory

Unit 1: Mechanisms of Behaviour **No. of hours: 6**

Definition of Proximate and Ultimate causes of behaviour; Innate behaviour: Instinct, Fixed Action Pattern (FAP); Learning: Associative learning: Classical and Operant conditioning; Non-associative learning: Habituation, Imprinting; Code breakers.

Unit 2: Patterns of Behaviour **No. of hours: 7**

Reflexes: Types of reflexes, reflex path, characteristics of reflexes (latency, after discharge, summation, fatigue,inhibition) and its comparison with complex behaviour. Orientation: Primary and Secondary orientation; Kinesis-orthokinesis, klinokinesis; Taxis-tropotaxis and klinotaxis; menotaxis (light compass orientation).

Unit 3: Social Behaviour and Sociobiology **No. of hours: 8**

Concept of Society; Degree of sociality; Insect society-Honey bee as example; Society organization and caste system, Polyethism vs Polymorphism; Dance as means of communication; Altruism and Reciprocal altruism; Hamilton"s rule and inclusive fitness with suitable examples.

Unit 4: Sexual Behaviour **No. of hours: 6**

Asymmetry of sex, Sexual dimorphism mate choice, Intra-sexual selection (male rivalry: competition, territoriality, infanticide), Inter-sexual selection (female choice), Consequences of mate choice for female fitness, Courtship Behaviour in stickleback fish.

Unit 5: Emotions **No. of hours: 3**

Concept of emotions, Emotional intelligence, Emotional Quotient (EQ) vs Intelligence Quotient (IQ); Components and theories of emotions

Practical

Credits: 2 **Total Hours: 60**

1. To study the nests and nesting behavior of any 5 birds.
2. To study the nests and nesting behavior of social insects (Wasps, Honeybees, Termites and Ants).
3. To study the behavioral responses of wood lice to dry and humid conditions.
4. To study Geotaxis behavior in earthworm/ Phototaxis behavior in insect larvae.
5. Study of various behavioral concepts (courtship, nesting, infanticide, territoriality) through shortvideos/films.
6. Study and actogram construction of locomotor activity of suitable animal models.
7. Construct an ethogram using suitable data to study animal behavior
8. Prepare a project report on the survey based on questions to study Emotional Quotient (EQ)
9. Visit to a Zoological Park to study and record the behavioral activities of animalsand prepare a short report.

Essential readings:

1. Alcock J. Animal Behaviour. Sinauer Associate Inc., USA.
2. McFarland D. Animal Behaviour. Pitman Publishing Limited, London, UK.
3. Vinod Kumar (2002) Biological Rhythms. Narosa Publishing House, Delhi/ Springer-Verlag, Germany
4. Manning, A., & Dawkins, M. S. (2012). An Introduction to Animal Behaviour. Cambridge: CambridgeUniversity Press.
5. Goodenough, J., McGuire, B., and Jakob, E. 2010. Perspectives on Animal Behavior. 3rd Edition. JohnWiley and Sons.
6. Passer, M.W. & Smith, R.E. (2010). Psychology: The science of mind and behaviour. New Delhi: TataMcGraw-Hill.

Suggested readings:

1. Mandal, F.B. (2015).Textbook of Animal Behaviour. Delhi: PHI Pvt. Ltd.
2. Sherman, P. W., & Alcock, J. (2013). Exploring Animal Behavior, Sinauer Associate Inc., Massachusetts.
3. Martin, P. and Bateson, P. 1986. Measuring Behaviour: An Introductory Guide. Cambridge University Press.
4. Dugatkin, L.A. 2013. Principles of Animal Behavior. 3rd Edition.WW Norton and Co

SEMESTER-V

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY THE DEPARTMENTS

GENERAL ELECTIVE COURSE –GE-3:

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Bioremediation and sustainability (BS-GE- 3)	**4**	**2**		**2**	Class XII pass	**NA**

Learning Objectives

This course will provide understanding of environment around and which pollutants are of concern to us . It will provide knowledge of sustainability and methods which can help to improve the sustainability. It will also make students understand how toxicity can be monitored in our body and how our body copes to detoxify its internal system. It will also introduce methods which can be used to monitor the pollutants in various samples.

Learning Outcomes:

Students will:

- Understand the various components of the environment.
- Understand and evaluate the local and global scale of environmental problem.
- Gain knowledge and skills necessary to understand multifaceted nature of environmental studies.
- Get informed perspective of biological, chemical and physical processes relevant to environmental problems.
- Get hands on experience of some quantitative and qualitative research tools to assess and analyse the environmental problems

Syllabus for GE-3

Theory

Credits: 2 **Total Hours: 30**

Unit 1: Introduction to Environment and the Pollutants **No. of hours: 8**

Normal Chemistry of - Air, Water, Soil. Environmental Toxins-Physical Pollutants- Noise, Light and

Radiation and Air Pollutants- Carbon Monoxide, Lead, Nitrogen Oxides, Ozone, Particulate Matter, Sulphur Dioxide, Methane Volatile Organic Chemicals (VOC); Water Pollutants - Volatile Organic Chemicals (VOC), Heavy Metals, Insecticides, Herbicides/ Endocrine Disruptors; Soil Pollutants- Heavy metals, Herbicides/pesticides, Polyaromatic Carbon (PAH), Microplastics; Source, Effect and Impact on Flora, Fauna including Human Beings. Definition of Terminologies: Air Quality Index (AQI) Suspended Particulate matter (SPM), Water Quality Index (WQI), Air Pollution Tolerance Index (APTI), Anticipated Performance Index (API).

Unit 2: Environment and Xenobiotics **No. of Hours: 8**

Understanding the principle of Toxicity. Concept of Dose and Response (LD50). Process of Bioaccumulation, Bioaugmentation and Biotransformation. Impact of pollutants on human health Mammalian Detoxification by Liver to Organic Chemicals (Heavy Metals, Endocrine Disruptors, Microplastics).

Unit 3: Sustainability and its Enhancement **No. of Hours: 8**

Concept of Sustainability and Enhancement of Sustainability, Waste Management (Refuse, Reduce, Reuse and Recycle), Bioremediation- Introduction and Types of Bioremediations- Phytoremediation, Microbial Bioremediation, In-situ Remediation, Ex-situ Remediation.

Unit 4: Techniques to Analyse Pollutants **No. of Hours: 6**

Determination of pollutants in soil, water, air, blood by following Analytical Techniques: Flame Photometer; Atomic Absorption Spectroscopy (AAS); Inductive Coupled Plasma (ICP) & Mass spectroscopy MS; Gas Liquid Chromatography (GC-MS); Ion Chromatography; High Performance Liquid Chromatography (HPLC); UV spectrophotometer; Biosensors and its application in pollution detection;

Practical:

Credits: 2 **Total Hours: 60**

1. Evaluating APTI and API of Herbs/Shrubs/Trees
2. Evaluating seasonal variations of AQI and SPM
3. Evaluating C/N/P/K content of soil by Spectrophotometry/Titrimetric method
4. Detecting Microbial Contamination of water
5. Composting of waste (Leaf/Kitchen Waste/Cow dung) and Detecting Maturity by pH and Electric conductivity (EC) content changes
6. Studying Enzymatic Activity (amylase/urease) in the soil sample due to microbial activity
7. Student Environment Projects.

Essential readings:

- Basic Concepts on Environmental Chemistry by Des. W. Conwell (2005) 2nd edition, CRC press, ISBN 9781498770484
- Environmental Chemistry by Stanley E Manahan, 11th Edition, Taylor and Francis,2022, ISBN 9780367560546
- Biodegradation and Bioremediation by Alexander Martin, 2nd Edition, Academic Press, ISBN 978-0-12-049861-8
- Fundamentals of Ecology author Eugene Odum, Cary W. Barrett, ,5th edition Cengage learning India. ISBN 9788131500200

- Environment and Ecology author P.D. Sharma, 12th Edition, Rastogi Publication. ISBN 978-93-5078-068-8

Note: Examination scheme and mode shall be as prescribed by the ExaminationBranch, University of Delhi, from time to time.

GENERAL ELECTIVE COURSE –GE-4:

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Epidemiology and Biostatistics (BS-GE- 4)	4	2		2	Class XII pass with Biology	NA

Learning Objectives

Throughout the course, students will explore different units of study, including Introduction to Epidemiology, Infectious Disease Epidemiology, Chronic Disease Epidemiology, Screening and Diagnostic Tests, Data Collection and Management, and Public Health and Epidemiology. They will learn about key concepts, study designs, disease surveillance, global health initiatives, and statistical analysis techniques relevant to each unit.
Practical exercises will further enhance students' skills and understanding. They will engage in case-control studies, outbreak investigations, estimation of sensitivity and specificity, analysis of vaccination coverage rates, hypothesis testing, and field visits to healthcare centers to gather data on disease rates. These practical experiences will provide hands-on application of epidemiological methods, fostering critical thinking and problem-solving abilities.

Learning Outcomes

Upon completion of this course, students will achieve the following learning outcomes:

1. Understand the principles of disease causation, with an emphasis on modifiable environmental factors. Students will be able to explain how various factors contribute to the development and spread of diseases, particularly focusing on the influence of the environment.

2. Apply epidemiology to disease prevention and health promotion, including environmental and occupational health. Students will recognize the importance of epidemiological approaches in identifying risk factors, implementing preventive measures, and promoting health in various settings.

3. Optimize the use of healthcare resources. Students will develop the skills to ensure that healthcare resources are effectively utilized by applying epidemiological knowledge to guide resource allocation, decision-making, and public health interventions.

Syllabus for GE-4

Theory

Credits 2 Total hours:30

Unit 1: Introduction to Epidemiology 3 hrs

Definition and scope of epidemiology, Basic concepts and principles of epidemiology, Measures of disease frequency and association, Study designs in epidemiology

Unit 2: Infectious Disease Epidemiology 6 hrs

Principles of infectious disease transmission, Outbreak investigation and response, Surveillance of infectious diseases, Vaccines and vaccine-preventable diseases, Emerging and re-emerging infectious diseases

Unit 3: Chronic Disease Epidemiology 8 hrs

Epidemiology of non-communicable diseases: Risk factors and determinants of chronic diseases, Cardiovascular diseases, Cancer epidemiology, Diabetes epidemiology, Mental health epidemiology, Environmental and Occupational Epidemiology

Unit 4: Screening and diagnostic tests 3 hrs

Screening test and diagnostic test, Sensitivity, specificity, Positive predictive value, Negative predictive value

Unit 5: Data collection and analysis 7 hrs

Introduction to biostatistics and its applications in epidemiology, Sources of epidemiological data, Measures of Variability, calculation of standard deviation, standard error and Co-efficient of Variance, Statistical errors, Chi-square test, Z test, t-Test

Unit 6: Public Health and Epidemiology 3 hrs

Introduction to public health, Role of epidemiology in public health practice, Disease prevention and control strategies, Epidemiological aspects of diseases of national importance ,Global burden of disease, Global health initiatives and organizations

Practical:

Credits: 2 Total hours: 60

1. Case-control study on a chronic disease: Design and conduct a case-control study to investigate the risk factors associated with a specific chronic disease (with given data)
2. Outbreak investigation simulation : Analyze a given simulated outbreak data, identify the source of infection, and propose control measures.
3. Sensitivity and specificity estimation: Analyze data from a diagnostic test evaluation study to estimate sensitivity, specificity, positive predictive value, and negative predictive value.
4. Collect data on vaccine coverage rates (public domain) in a population and analyze the results to assess the effectiveness of vaccination programs.

5. Hypothesis testing: Perform hypothesis tests (e.g., chi-square test, t-test) on provided datasets to analyze associations or differences between groups.
6. Field visits to nearby health care centres to understand health check-ups and collect some data on the rate of a particular disease over the past few months or years.

Essential reading

1. Aschengrau A, Seage G.R., (2013) Essentials of Epidemiology In Public Health, Jones and Bartlett Publishers, Inc; (3rd ed.) ISBN-10: 1284028911; ISBN-13:978-1284028911.

2. Sullivan. L.M. (2017) Essentials of Biostatistics in Public Health. Jones and Bartlett Publishers, Inc; (3rd ed.) ISBN-10: 1284108198; ISBN-13: 978-1284108194.

Note: Examination scheme and mode shall be as prescribed by the ExaminationBranch, University of Delhi, from time to time.

SEMESTER -VI

Category I

Biological Science Courses for Undergraduate Programme of study with BiologicalScience as a Single Core Discipline

(BSc Honors in Biological Science in three years)

DISCIPLINE SPECIFIC CORE COURSE – 16:

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Molecular Biology II (601)	**4**	**2**		**2**	Class XII Pass with Biology & Chemistry	**Should have done Molecular biology I**

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the students to the students the basic knowledge about how genes are transcribed and how translation takes place in prokaryotes and eukaryotes.
- To understand how these processes are regulated.
- To enable them to apply this knowledge in enhancing their analytical and problem- solving skills.

Learn **CREDITS:2** **TOTAL HOURS: 15 weeks** ing outcomes

On successful completion of the course, students will be able to:

1. Acquire basic knowledge about the processes of transcription and translation in prokaryotes and eukaryotes
2. Learn about the features of the genetic code and various experimental approachesused to crack the code
3. Develop understanding of the molecular basis of RNA processing and RNA splicing
4. Learn about the various ways in which these biological processes are regulated and the significance of regulation in maintaining life forms

SYLLABUS

FOR DSC-16

UNIT I: Transcription in Prokaryotes and Eukaryotes **No. of hours :10**

Transcription cycle in bacteria, Sigma factor, bacterial promoters and RNA Polymerases, various stages of RNA synthesis- initiation, elongation and termination, rho-dependent and rho-independent termination. Introduction of basal eukaryotic transcription machinery: threeclasses of eukaryotic RNA polymerases – I, II and III, and their respective promoters. Details of transcription by RNA polymerase II, features of RNA polymerase II core promoters. Inhibitors of eukaryotic and prokaryotic transcription and their applications.

UNIT II: RNA Processing **No. of hours : 4**

Various types of mRNA processing- polyadenylation and capping, brief overview of rRNA andtRNA processing. Chemistry of RNA splicing, the spliceosome machinery, group I and group IIintrons, alternative splicing.

UNIT III: Translation **No. of hours: 7**

Salient features of the genetic code, triplet nature, degenerate, wobble hypothesis, codon usage bias. Experimental approaches used to decipher the genetic code. Messenger RNA, transfer RNA, charging of tRNA. Structure of the ribosome. Three stages of translation- initiation, elongation and termination in prokaryotes and eukaryotes, charging of tRNA and aminoacyl tRNA synthetases.

UNIT IV: Regulation of gene expression **No. of hours: 9**

Concept of operons, regulatory proteins, activators, repressors, DNA binding domains,regulation of *lac* and *trp* operon, riboswitches, induction of SOS response. Eukaryotic gene regulation by chromatin remodeling, heterochromatin and euchromatin, regulation of galactose metabolism genes in yeast, action of enhancers and insulators, working of activatorsand repressors, synthesis and mechanism of action - siRNA and miRNA.

PRACTICAL:

Credit: 2 **Total Hours: 60**

1. Quantitative estimation of RNA by Orcinol Method
2. Extraction of total RNA from bacteria /yeast
3. To study growth curve and diauxic growth curve in *E. coli*
4. To study the effect of inhibitors on protein synthesis

5. DNA Footprinting (Dry Lab)

Essential readings:

1. Nelson, D.L. and Cox, M.M (2017) *Lehninger: Principles of Biochemistry* (7th ed.) W.H. Freeman & Company (New York), ISBN:13: 9781464126116 / ISBN:10-1464126119.
2. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008) *Watson: Molecular Biology of the Gene* (7th ed.), Cold Spring Harbor Laboratory Press, Cold spring Harbor (New York), ISBN:0-321-50781 / ISBN-13: 9780321762436

Suggested readings:

Lewin, B., Krebs, J.E., Kilpatrick, S.T., Goldstein, E.S., (2018) *Lewin's Gene X* (10th edition).Bartlett Learning publishers, LLC, ISBN: 978-0-7637-6632-0.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, Universityof Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 17

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Defense mechanisms in living organisms (BS-DSC-602)	**4**	**2**		**2**		**SEM V**

Learning Objectives

The Learning Objectives of this course are as follows:

- to focus on the integrative working and regulation of both the innate and induced/adaptive defense mechanism that operate in the vertebrate system as well as in the plant kingdom.
- to differentiate between innate and induced/adaptive immune mechanisms and their importance in maintaining a healthy system in both the animal and plan tkingdoms.

Learning outcomes

Upon completion of the course, the students will be able to:

- Get an overview of the immune system and learn about the various cells, organs and tissues of the immune system.
- to describe the basic mechanisms, differencesand functional interplay of innate and adaptive immunity.
- Students will be able to define the pathways of humoral and cell-mediated immune responses.
- Students will learn about the various preexisting structural and induced defenses in plants, the genetic basis of plant- pathogen interaction and how pathogens can cause disease in plants.

SYLLABUS OF DSC- 17

Theory

TOTAL HOURS: 30 **CREDITS: 2**

Unit I: Introduction to Defense Mechanisms **No. of weeks: 1**

Overview of immunity. Source of infection and spread of infection in plants and animals.

Unit II: Innate Defense mechanisms in plant **No. of weeks: 2.5**

Pre-existing structural defenses -waxy coat, cuticle, epidermal layer, hydathodes, thorns, sclereids,mineral crystals (idioblasts,) and cell wall. Biochemical defenses- secondary metabolites (terpenoids, glycosides, phenolics and alkaloids) Innate Immunity in Plants- Pattern triggered immunity (PTI)

Unit III: Adaptive Defense mechanisms in plant **No. of weeks: 4**

Factors causing plant stress: biotic stress. Classification of biotic stresses, major pests and diseasesof economically important crops, interaction in host-pathogen systems, Flor's gene for gene concept, R gene mediated resistance, effector triggered immunity (ETI), receptor-elicitor model, Cytological protection and induced resistance. Concept of signal transduction and other host- defense mechanisms. Heat shock proteins, Basic ROS cycle and adaptation during stress, SystemicAcquired Resistance (SAR), Phytoalexins Jasmonic acid, MAPKS,SROS,HPL, systemins , mechanism of production and scavenging of NO.

Unit IV: Innate Defence mechanisms in animals **No. of weeks: 3**

Anatomical barriers, soluble molecules and membrane associated receptors (PRR). Complement system - biological consequences and regulation of the pathway. Haematopoiesis, cells of the innate immune system, primary lymphoid organs. inflammatory response; connections between innate and adaptive immunity.

Unit V: Adaptive Defence mechanisms in animals **No. of weeks: 4.5**

Antigens and haptens, Factors that dictate immunogenicity, B and T cell epitopes. Structure and distribution of classes of immunoglobulins (Ig). Secondary lymphoid organs and tissues B cell maturation and generation of antibody diversity. Generation of humoral immune response. Histocompatibility antigens – structure and function, T cell maturation – Positive and Negative selection of thymocytes, Antigen Presentation by the exogenous and endogenous pathways, cell mediated immunity, role of NK cells and Antibody dependent cellular cytotoxicity.

PRACTICALS

TOTAL HOURS: 60 **CREDIT: 2**

1. Characterization of diseases symptoms and identification of pathogenic organisms (bacterial- Xanthomonas campestris; viral- TMV; fungal- Puccinia, graminis tritici, pest and nematodes- Meloidogyne spp.).
2. Survey of structural plants defences: viz. cuticle, wax, lignin, bark, thorns, prickles, trichomes, armour in different plants species including thigmonasty, camouflage, mimicry.

3. Precipitation reactions – DID and SRID.
4. Immunoelectrophoresis (IEP), Counter current IEP, Rocket IEP
5. Agglutination reaction.
6. Cell isolation and viable Counting- Spleen/PBMC
7. Survey report on infections in plants and animals

REFERENCES

1. B.B.Buchanan, W. Gruissem & R.L.Jones. (2015). Biochemistry and MolecularBiology of Plants. Oxford: Wiley Blackwell.
2. Coico, R & Sunshine, G., John (2009). Immunology: A Short Course. New Jersey:Wiley& sons.
3. Kindt, T.J., Goldsby, R.A. & Osborne, B.A.(2007) . Kuby Immunology. New York: W.H Freeman.
4. Leslie Hudson & Frank C. Hay (1980). Practical Immunology. Oxford: Blackwell Scientific 5. Lincoln Taiz & Eduardo Zeiger.(2010). Plant Physiology. Sunderland,Mssachusetts: Sinauer associates Inc.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch,University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE –18 :

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibilitycriteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Evolutionary Biology(BS-DSC-603)	4	2		2	Class XII pass with Biologyand chemistry, as one of the papers in Class XII	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- To stress the importance of evolution in biology and introduce students to all aspects of evolutionary biology.
- to make the students familiar with basic history of evolutionary concept, its criticism and its development as a science.
- They will learn about history of life through fossils and other evidences helping them analyze the evolutionary relationships between species.
- They will develop a deep understanding of the mechanisms that fuel the evolution of biological systems and will have an insight into the origin and evolution of species.

Learning outcomes

By the end of the course, the student will be able to:

- Students will learn about the origins and development of evolutionary thought.
- Students will learn about the compelling evidence in favor of evolution likefossils, comparative anatomy and molecular homologies.
- Students will learn about the origin and history of life through fossil records.
- Students will understand how biodiversity is generated by repeated speciation andlost over time due to mass extinctions.
- Students will understand how the forces of evolution like variations, naturalselection, genetic drift and migration shape populations.
- Students will learn how novelty in organisms arises, how organisms adapt to theirenvironment and about our origins from our primate ancestors.

SYLLABUS OF DSC-18

Theory

Credits: 2 Total weeks: 15

Unit I: Historical Review of Evolutionary Concept **No. of hours: 3**

Pre-Darwinian ideas: List of contributors influencing Darwin indicated as a *timeline.* Lamarckism: Darwinism: Post-Darwinian era: Modern synthetic theory; Neo-Darwinism.

Unit II: History of Life **No. of hours: 7**

Chemogeny: An overview of prebiotic conditions and events; experimental proofs to abiotic origin of micro- and macro-molecules. Current concept of chemogeny: RNA firsthypothesis. Biogeny: Cellular evolution based on proto-cell models (coacervates and proteinoid microspheres). Origin of photosynthesis, Evolution of oxygen and ozone buildup and significance. Evolution of Eukaryotes from Prokaryotes (endosymbiotic theory), multicellularity. Cambrian explosion and timeline of plant and animal evolution in the Phanerozoic eon. Mass-scale extinctions: causes, significance and events. Cretaceous-Tertiary Mass Extinction in detail.

Unit III: Evidences of Evolution **No. of hours: 5**

General evidences, Fossils, Concept of Stratigraphy and geological timescale, Dating methods (K-Argon and Radiocarbon dating); Convergent and Divergent Evolution, Adaptiveradiation, Phylogeny of horse as a model. Molecular clock, Neutral theory of evolution and;Basics of molecular phylogenetics.

Unit IV: Forces of Evolution **No. of hours: 6**

Concept of micro- and macro-evolution (Role of gene regulation in macroevolution usingexample of beak development in Darwin's finches): A brief comparison Natural selection asa guiding force: Its attributes and action, basic characteristics of natural selection. Co-adaptation and co-evolution, Industrial melanism; antibiotic resistance. Modes of selection(Stabilizing, directional, disruptive), sexual selection, kin selection, artificial selection, Polymorphism and Balanced lethal systems.

Hardy Weinberg equilibrium,Genetic Drift (Sewall Wright effect) as a stochastic/randomforce: Basic characteristics of drift; selection vs. drift, Bottleneck effect, Founder principle.

Unit V: Product of Evolution: Speciation **No. of hours: 5**

Concept of species as a real entity- Morphological and Biological species concept, Micro- evolutionary changes (inter-population variations, clines, Ring species, Races, polymorphism)Mechanisms of speciation, Allopatric, Peripatric, Parapatric and sympatric; Patterns of speciation. Anagenesis and Cladogenesis; Phyletic Gradualism and Punctuated Equilibrium (Quantum Evolution), Basis of speciation: Isolating mechanisms

Unit VI: Human Ancestry and Phylogeny **No. of weeks: 4**

Primate characteristics and unique Hominin characteristics. Advantages and adaptations of bipedalism. General characteristics , distribution of Australopithecines, Homo habilis, Homoergaster, Homo erectus (Java Man , Peking man), Neanderthal man and Homo sapiens. Briefoverview of

Multiregional and Out of Africa hypothesis for origin and migration of Modern humans.

PRACTICALS
TOTAL HOURS: 60 **CREDITS: 2**

1. Study of types of fossils (e.g. Body fossils, trails, casts, molds and others) and Index fossils of Palaeozoic era
2. Connecting links/transitional forms - *Eg. Euglena, Neopilina, Balanoglossus, Chimaera, Tiktaalik, Archaeopteryx and* Living fossils - Eg. *Limulus, Peripatus*, *Latimeria, Sphaenodon*
3. Vestigial, Analogous and Homologous organs using photographs, models orspecimen
4. Problems based on Hardy Weinberg equilibrium
5. Simulation experiments using colored beads to understand the effects of Naturalselection on allele frequencies
6. Simulation experiments using colored beads to understand the role of Bottleneckeffect/Founder effect on allele frequencies
7. Darwin's finches with diagrams/ cutouts of beaks of different species.
8. Digit reduction and teeth modification in horse phylogeny (study from chart),
9. Study of monkey and human skull - A comparison to illustrate common primate andunique Hominin features
10. Construction of Phylogenetic tree using morphological characters
11. Educational visit to Geology/ Anthropology museums, Delhi University

Essential readings:

1. Barton N.H., Briggs D.E.G., Eisen J.A., Goldstein D.B. and Patel N.H.,(2007)1stEd. *Evolution*, Cold Spring Harbor Laboratory Press.
2. Futuyma Douglas and Mark Kirkpatrick (2017) 3rd Ed.*Evolutionary Biology*,Oxford University Press
3. Hall B. K. and Hallgrimson B., (2014) 5thEd.*Strickberger's Evolution.* Jones and Bartlett
4. Ridley M., (2003) 3rdEd.*Evolution* Wiley-Blackwell
5. Zimmer C. and Emlen D. J., (2013) 1stEd. *Evolution: Making Sense ofLife*, Roberts & Co.

Additional resources

1. Darwin C., (2003)*The Origin of Species: 150th Anniversary Edition* , PenguinUSA
2. https://evolution.berkeley.edu/evolibrary/home.php
3. Kolbert E., (2015)*The Sixth Extinction: An Unnatural History,* Bloomsbury
4. Weiner J. (1995),*The Beak of the Finch: A Story of Evolution in Our Time*, Vintage

Note: Examination scheme and mode shall be as prescribed by the Examination Branch,University of Delhi, from time to time.

POOL OF DSE

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-10

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant development and anatomy (BS-DSE-10)	**4**	**2**		**2**	Class XII pass with Biology and chemistry, as one of the papers in Class XII	**NA**

Learning Objectives:

The objective of this paper is to provide the students with internal basic structure and cellular composition ofthe plant body. This will help them to understand how different plant tissue structures evolve and modify theirfunctions with respect to the environment. To acquaint the students with the study of various plant tissue systems and their development and functions in plants.

Learning Outcomes:

On successful completion of the course, a student will:

- Have knowledge about the various cells and tissues, meristems, epidermal and vascular tissue systemsin plants.
- Understand various aspects of growth, development of the tissues and differentiation of various plantorgans.
- Have knowledge of basic structure and organization of plant parts in angiosperms.
- Correlate the structure with morphology and functions.

SYLLABUS FOR DSE-10

Course Contents - Theory

Unit 1: Meristematic and Permanent Tissues **No. of hours: 10**

Classification of Tissues, Simple and complex tissues (no phylogeny), Types of meristems: Root and Shoot Apical Meristems (describe theories in brief with special reference to Tunica Corpus andKorper-Kappe Theory), Pits and plasmodesmata, wall ingrowths and transfer cells, Ergastic substances

Unit 2: Secondary growth **No. of hours: 10**

Vascular Cambium: Structure and function, seasonal activity; Structure of monocot and dicot stem, root and leaf; Secondary growth in root and stem; wood (Heartwood and Sapwood; Tension wood; Ring and Diffuse porous wood; early and late wood); Tyloses Cork Cambium and its derivatives and function: Rhytidome

Unit 3: Adaptive and Protective Systems **No. of hours 10**

Epidermal tissue system; Cuticle; Epicuticular waxes; Trichomes (Uni and multicellular, glandular and non- glandular, two examples of each); secretory tissues (hydathodes, mucilage ducts, resin ducts, oil glands, laticifers, lysigenous and schizogenous cavities); Stomata (Classification); Adcrustation and Incrustation; Anatomical adaptation of xerophytes and hydrophytes.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Study of root and shoot apical meristem through permanent slides. Study of distribution and types ofParenchyma, Collenchyma and Sclerenchyma through permanent slides.
2. Study of xylem and phloem elements through maceration.
3. Study of primary growth in Monocot and Dicot stem through temporary mounts
4. Study of secondary growth in Dicot stem through temporary mounts
5. Study of Monocot and Dicot root through temporary mounts – Primary growth
6. Study of secondary growth in Dicot root through temporary mounts
7. Study of isobilateral and dorsiventral leaf through temporary mounts/permanent slides
8. Study of different types of wood (ring porous; diffuse porous; tyloses; heartwood and sapwood)through permanent slides/museum specimens.
9. Study of stomata types through epidermal peel mount.
10. Study of trichomes (glandular and non-glandular), cystoliths, druses, raphides, starch grains, sclereidsand stone cells through permanent slides
11. Study of anatomical adaptations in Hydrophytes (*Nymphaea* or *Hydrilla*) and Xerophytes (*Nerium*leaf).

Essential Readings

i. Dickinson, W.C. (2000). *Integrative Plant Anatomy.* Cambridge, U.K. : Harcourt Academic Press.
ii. Esau K. (1977). *Anatomy of Seed Plants.* New Delhi, Delhi: John Wiley & Sons, Inc.
iii. Evert, R.F., Eichhorn, S.E. (2006). *Esau's Plant Anatomy: Meristems, Cells, and tissues of the plantbody: their structure, function and development.* New Jersey, U.S.: Wiley-Liss.
iv. Fahn, A. (1974). *Plant Anatomy.* Pergmon Press, USA and U.K.

Suggested Readings

1. Mauseth, J.D. (1988). *Plant Anatomy.* San Francisco, California: The Benjammin CummingsPublisher.
2. Raven, F.H., Evert, R.F., Eichhorn, S.E. (1992). *Biology of Plants.* New York, NY: W.H. Freemanand Company.

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-11

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Pharmacology and Toxicology (BS-DSE-11)	**4**	**2**		**2**	Class XII pass with Biology and chemistry, as one of the papers in Class XII	**NA**

Learning Objectives:

This is an introductory course to lay the foundation for understanding basic concepts in Pharmacology and thepharmacological basis of therapeutics. The objective of the course is to introduce students to the core principles of drug action in terms of bioavailability, pharmacokinetics, pharmacodynamics, and mechanism of action of drugs in the treatment of diseases. The course will also provide basic principles of toxicology, toxic substancesand their effects on body systems.

Learning Outcomes:

On successful completion of the course, a student will:

- Understand the basic scientific concepts and principles that serve as the foundational underpinnings of the pharmacological sciences including pharmacokinetics; pharmacodynamics; drug metabolism; and drug-drug interactions.
- Learn an introduction to the processes by which new drugs are discovered.
- Understand the specific pharmacology of the major drugs and drug classes currently used in medical practice including their indications, clinical use and mechanisms of action,
- Discuss the basic principles of toxicology; the mechanisms by which excess exposure to certain drugs,toxins, chemicals, heavy metals and poisons can lead to adverse toxicological effects

SYLLABUS FOR DSE-11
Course Contents -Theory

Unit 1: Introduction to Pharmacology **No. of hours: 5**

History and Scope of Pharmacology, Nature and source of drugs, Routes of drug administration, Drugreceptors and receptor subtypes, Drug Discovery and Development, Computer Aided Drug Design

Unit 2: Pharmacokinetics and Pharmacodynamics **No. of hours 8**

Absorption, Distribution, Metabolism, and Excretion (ADME) of drugs. Bioavailability, First Passmetabolism, Biological half-life of drug and its significance, Drug-drug interactions.

Unit 3: Drug Classification and their mechanism of action **No. of hours: 10**

Drugs of Inflammation: Analgesics and Anti-inflammatory Drugs, NSAIDs; Drugs of autonomic and central nervous system -Adrenergics: Isoprenaline, Propranolol; Dopaminergics, Dopamine, Syndopa; General Anesthetics: Halothane; Sedatives and Hypnotics: Diazepam; Cholinergics: Bethanechol, Rivastigmine; Anticonvulsant, Drugs of Cardiovascular system: Anticoagulant (Heparin, Warfarin) Blood Pressure LoweringDrugs (Diuretics, Reserpine), Lipid Lowering Drugs (Statin); Drugs of Gastro-Intestinal tract: Antacid(Cimetidine), Acid Blocker and Laxative ;Drugs of Renal functions: Diuretics; and Anticancer Drugs (Cistatin,Methotrexate, 5-fluorouracil).

Unit 4: Toxicology **No. of hours:7**

Classification of toxic substances, Drugs, Toxins and Heavy metal poisoning, Xenobiotics, Mechanism of toxicity, Tolerance to toxicants, Dose-response relationship, Therapeutic Index, Bioaccumulation and Antidotes.

3.1 PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. To study the presence of paracetamol (acetaminophen) in given sample by spectroscopic method
2. Determination of LD50/LC50 of antibiotic/drug
3. Model Systems to study Dose-Response
4. Drug Binding assay to Albumin by Spectroscopic Analysis
5. Effect of heavy metal/toxin on enzyme activity
6. Colchicin effect on cell division.
7. Case Studies in Toxicology
8. Small Molecule Databases mining and Protein-ligand Docking
9. Visit to Pharmaceutical or Toxicology laboratory

3.2 Essential Readings

1. Tripathi, K.D. (2010). 7th Edition. Essentials of medical pharmacology. Delhi, India: Jaypee Brothers.ISBN-13:9788184480856.
2. Katzung, Bertram G. , Basic &Clinical Pharmacology, 14th Edition, McGraw Hill Education, 2017
3. Klaassen, C. D. and Watkins J. B. (2021), 4th Edition, Casarett & Doull's Essentials of Toxicology NewYork, USA: McGraw Hill.ISBN: 978-1-26-045229-7.
4 Kulkarni, S.K. (2012). 4th Edition. Handbook of experimental pharmacology. Delhi, India: VallabhPrakashan, ISBN-13: 97881857311.

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-12

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Developmental Biology (BS-DSE-12)	4	2		2	Class XII pass with Biology and chemistry, as one of the papers in Class XII	NA

Learning Objectives:

The main objective of Developmental Biology course is to provide four-dimensional thinking of students to truly understand the patterns and process of embryonic development, body plan, fate map, induction, competence, regulative and mosaic development, molecular and genetic approach for the study of developing embryo which is not necessarily shared with any other disciplines in the biological sciences. The relevance of Developmental Biology to the study of human disease will be exemplified throughout using different model organisms.

Learning Outcomes:

Upon completion of the course, students will be able to:

- Understand the fundamental processes that underpin the fertilization of an egg cell and its step-by-step transformation into the fascinating complexity of a whole organism.
- Learn how a cell behaves in response to an autonomous determinant or an external signal depends on the combination of transcriptional and posttranscriptional regulators, signaling pathway components, cytoskeletal elements, and other proteins and RNAs that it has synthesized earlier: i.e., on its developmental history. Students learn best by doing and by having the opportunity to put what they havelearned into practice. Therefore, various model organism will be used as a learning tool.
- Understand that cells only express a proportion of their genome, and that differential gene expression underlies cell differentiation and any alteration in the entire process of development leads to devastating diseases.

SYLLABUS FOR DSE-12
Course Contents- Theory

Unit 1: Introduction **No. of hours: 5**

Historical perspective and basic concepts of developmental biology: cell division, cell differentiation, morphogen and morphogenetic gradient, patterning; EVO-DEVO concept. Model organisms

Unit 2: Early Embryonic Development **No. of hours: 10**

Post fertilization events: Planes and patterns of cleavage; Types of Blastula; Fate maps (including Techniques); Early development of frog and chick up to gastrulation; Embryonic induction and organizers

Unit 3: Late and post Embryonic Development **No. of hours: 10**

Fate of Germ Layers; Formation of neural tube and neural tube defects , Formation of Extra-embryonic membranes in birds; Placenta (Structure, types and functions of placenta) Modes of regeneration-epimorphosis,morphallaxis and compensatory regeneration (with one example each). Aging- genes involved in alteration in timing of senescence

Unit 4: Gene regulation in development No. of hours: 5 Axis specification in Drosophila: role of maternal genes, patterning of early embryo by zygotic genes: gapgenes, pair-rule genes, segment polarity genes, homeotic selector genes- bithorax and antennapedia complex.

3.1 PRACTICAL

Credit: 2 **Total Hours: 60**

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages)
2. Study of whole mounts of developmental stages of chick through permanent slides (Hamburger and Hamilton Stages): Stage 3 (Intermediate Streak)-13 hours, Stage 4 (Definitive Streak)-18 hours, Stage 5 (Head Process)-21 hours, Stage 7-24 hours, Stage 8-28 hours, Stage10-33 hours, Stage 11-40 hours, Stage 13-48 hours, Stage 19- 72 hours and Stage 24-96 hours of incubation
3. Demonstration of culture of chick embryo from fertilized eggs to study various developmental stages.
4. Study of the developmental stages and life cycle of Drosophila from stock culture.
5. Study of different sections of placenta (photomicrographs/ slides).
6. Project report on Drosophila culture/chick embryo /Zebra fish development.
7. A visit to Poultry Farm/IVF Centre/Zebra fish lab

3.2 Essential readings:

1. Gilbert, S. F. (2010). Developmental Biology. IX Edition, Sinauer Associates, Inc. Publishers,Sunderland, Massachusetts, USA
2. Balinsky B. I. and Fabian B. C. (2006). An Introduction to Embryology. VIII Edition, InternationalThompson Computer Press.
3. Slack, J.M.W. (2013) Essential Developmental Biology. III Edition, Wiley- Blackwell.

Suggested Readings:

1. Wolpert, L. (2002). Principles of Development. II Edition, Oxford University Press.
2. Kalthoff, K. (2001). Analysis of Biological Development. II Edition, McGraw Hill Publishers.
3. Carlson, B.M. (2007) Foundations of Embryology. VI Edition, Tata McGraw-Hill Publishers.
4. Arora, R. and Grover, A. (2018) Developmental Biology: Principles and Concepts. I Edition, R. Chand& Comp

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-19

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Research Methodology (BS-DSE-12)	4	2		2	Class XII pass with Biology and chemistry, as one of the papers in Class XII	NA

Learning Objectives:

The main objective of this paper is to provide students with a general introduction to the methodological foundations and tools used in research for an understanding of the ways to identify problems, develop hypotheses and research questions and design research projects. The course will expose students to the range of designs used in research in laboratory, field experiments, surveys and content analysis. It will also provide an introduction to the concept of controls, statistical tools and computer applications used in research. In addition, the course will impart knowledge of scientific writing, oral presentation and the various associated ethical issues.

Learning Outcomes:

Upon completion of the course, students will be able to:

- Define research, learn the importance of research and its link with theoretical knowledge
- Describe the research process and the principle activities, skills and ethics associated with the researchprocess
- Describe and compare the major quantitative and qualitative research methods
- Construct an effective research proposal
- Understand the importance of research ethics use the computer software for organization and analysisof data.
- Develop skills in the art of scientific writing and oral presentation

SYLLABUS FOR DSE-19
Course Contents- Theory

Unit 1: Introduction to Research **No. of hours: 4**

Objectives and characteristics of research; significance of research, types of research methods- qualitative andquantitative; basic and applied; descriptive and analytical; various phases of research-problem identification, generation of hypothesis, experimental design, results and discussion. Writing a research proposal-schematic presentation.

Unit 2: Basic principles of research design **No. of hours: 8**

Review of literature using appropriate sources – reviews, patents, research papers, books and e-resources; Significance of controls in research, Types of research designs – exploratory, descriptive, experimental, surveyand case study.

Unit 3: Statistical tools and Report writing **No. of hours: 12**

Data collection, analysis and graphical presentation; Sample – types and characteristics; Basic Statistical Tools
- Measures of central tendency, Arithmetic mean, Median, Mode, Standard deviation, Co-efficient of variation (Discrete serious and continuous serious), Correlation, Regression, Multiple Regression, hypothesis testing, P-value, data analysis and interpretation; Report writing, format of publications and presentations-oral and poster.

Unit 4: Scientific conduct and ethics in Research **No. of hours: 6**

Biosafety and Ethics - compliance and concerns; Plagiarism-Software tools and Creative Commons; Introduction to Intellectual Property Rights; Citation and acknowledgement, Impact factor, h-index, Indianand international funding agencies.

3.1 PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Use of search engine tools for retrieving research papers
2. Preparation of bibliography in different formats
3. Use of Plagiarism tools
4. Design of a research survey on a specific problem
5. Writing a concept note / research proposal
6. Writing of a mini-review paper
7. Systematic review, meta data analysis and presentation
8. Poster/oral presentations

3.2 Essential readings

1. Cresswell, J. (2009) *Research Design : Qualitative and quantitative Approaches* Thousand Oaks CA,(3rd ed.), Sage Publications
2. Kothari, C.R. (2004) *Research Methodology: Methods and Techniques* (2nd ed.), New AgeInternational Publishers.
3. Kumar, R. (2011) *Research Methodology: A Step-by-Step Guide for Beginners* (5th ed.), SAGEpublisher
4. Walliman, N. (2017*) Research Methods: The Basics,* (2nd ed.), London ; New York : Routledge
5. *WHO (2001) Health Research Methodology – A Guide for Training in Research Methods.*

B.Sc (Hons.) Biomedical Science
Discipline Specific Core (BIOMED-DSCs)
(ACBR)
SEMESTER- IV

DISCIPLINE SPECIFIC CORE COURSE -10 (BIOMED-DSC-10) IMMUNOBIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Immunobiology BIOMED-DSC-10	4	3	-	1	XII Pass with Physics, Chemistry & Biology	Basic knowledge of biology

Learning objectives

The students will learn

- The organization and functioning of the immune system and its branches- Innate and Humoral, its complex network of cells, molecules, tissues and organs
- Various Immunological techniques and their applications
- Various types of vaccine based immunotherapies

Learning outcomes

Having successfully completed this course, students shall be able to learn

- The human immune system and its components and how the immune system responds to 'non-self' entities.
- The principle, methodology and applications of various laboratory techniques involving antigen-antibody reaction.
- Various types of vaccine based immunotherapies will help them to think about new approaches for combating pathogens.

SYLLABUS OF BIOMED-DSC-10:

Unit I: Overview of Immune System (05 hrs)

Historical background, general concepts of the immune system, innate and adaptive immunity, primary and secondary immune response, active and passive immunity. Haematopoiesis

Lymphoid Organs: Thymus, Bone marrow, Lymph nodes, Spleen, MALT, GALT and SALT.

Unit II: Innate Immune response **(10 hrs)**

Physical and Chemical barriers.

Cells of the innate immune system: NK cells, Monocytes and Macrophages; Neutrophils, Eosinophils, Basophils, Mast cells and Dendritic cells.

Complement system: Components of the complement activation-classical, alternative and lectin pathways; biological consequence of complement activation.

Introduction to Pathogen Associated Molecular Pattern and Pattern Recognition Receptors Mechanisms of pathogen killing by macrophages and neutrophils.

Concept of inflammation.

Unit-III Antigens and their presentation in immune responses: **(06 hrs)**

Antigenicity and immunogenicity, haptens. Properties (foreignness, molecular size, heterogeneity, route and dose of administration, solubility and degradability); Types of antigens.

Major Histocompatibility Complex: Genome Organization of MHC and inheritance in humans; concepts of polygeny and polymorphism with respect to MHC and its contribution in survival of host population.

Antigen presenting cells, antigen processing, loading (Bimolecular complex formation) and presentation pathways (cytosolic and endocytic).

Unit IV: Adaptive Immune Response **(10 hrs)**

Cells of the adaptive immune system: T and B lymphocytes, Characteristics of adaptive immune responses.

Humoral immune response: Stages of B cell development in bone marrow, stages of B cell activation in the secondary lymphoid organs. Antibodies: structure, function and properties of the antibodies; different classes (isotypes) and subclasses. Biological activities of antibodies, concepts of antibody diversity, monoclonal and polyclonal antibodies, Hybridoma technology.

Cell mediated immune response: Major steps in T cell differentiation in thymus- thymic selection, self MHC restriction, T cell receptor complex. Phenotypic characteristics of naïve T-cells ($CD4^+$ and $CD8^+$ T-cells). Stages of activation of naïve T-cells in secondary lymphoid organs and effector functions of $CD4^+$ and $CD8^+$ T lymphocytes.

Basic introduction and properties of cytokines: IL-2, IL-4 and IFN-γ.

Concept of hypersensitivity.

Unit V: Principles of Antigen- Antibody Interactions and Techniques (09 hrs)

Basic concepts of antigen-antibody interactions (epitope-paratope), Affinity and avidity, cross reactivity, precipitation, agglutination, immunodiffusion, ELISA, ELISPOT, western blotting.

Unit VI: Vaccines (05 hrs)

Contribution of Sir Edward Jenner and Louis Pasteur in vaccine development. Major types of vaccine and their characteristics, adjuvants. National Immunization programme.

Practical (30 hrs)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Virtual demonstration of lymphoid organs and phagocytosis.
2. To perform immuno-diffusion by Ouchterlony method.
3. To perform Immuno-diffusion by Mancini method.
4. To perform Lateral Flow assay/ Immunochromatography.
5. To perform Complement fixation assay.
6. To perform direct (blood group) agglutination assay.
7. To perform indirect (Widal test) agglutination assay.
8. To perform sandwich dot ELISA

Essential readings:

- Delves, P.J. Martin, S.J. Burton, D.R. and Roitt, I. M. (2017). 13th Edition. *Roitt's Essential Immunology*. New Jersey, USA: Wiley-Blackwell Science. ISBN: 13: 978- 1118415771.
- Punt, J. Stranford, S. Jones, P. and Owen, J. (2019). 8th Edition. *Kuby Immunology*. New York, USA: W.H. Freeman and Company. ISBN- 13: 978-1464189784.

Suggestive readings:

- Kindt T. J., Osborne B. A. , Goldsby R. A. (2007). 6th Edition *Kuby Immunology*. New York, USA: W.H. Freeman and Company. ISBN-13: 978-1429202114 ISBN-10: 1429202114.

- Willey, J. Sherwood, L and Woolverton, C.J. (2016). 10th Edition. *Prescott's Microbiology*. New York, USA: McGraw-Hill Education. ISBN-13: 978-1259281594.
- Hay, F.C. and Westwood, O.M.R. (2002). 4th Edition. *Practical Immunology*. New Jersey, USA: Blackwell Science. ISBN: 9780865429611.

DISCIPLINE SPECIFIC CORE COURSE –11 (BIOMED-DSC-11) MOLECULAR BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/Practice		
Molecular Biology BIOMED-DSC-11	4	3	-	1	XIIth Pass with Physics, Chemistry & Biology	Basic knowledge of biology

Learning objectives

- The objective of the course is to offer detailed and comprehensive knowledge about the mechanisms of DNA replication, repair, transcription and translation in prokaryotes and eukaryotes so that students can apply this knowledge in enhancing their analytical and research problem solving skills.
- As the course progresses, students would comprehend the basic mechanism of DNA replication in prokaryotes and eukaryotes along with associated discerning features.
- Students would also understand the mechanism of introduction of mutations and how these are repaired inside the cell.
- Students would be able to understand that, molecular biology as a field started with an in-depth research and studies on prokaryotes and only recently our understanding of life processes in eukaryotes have increased considerable.

Learning outcomes

- This course focuses on the molecular processes involving biomolecules and provides students with a range of theoretical knowledge and associated practical skills.

- Students would comprehend biological processes such as Replication, Transcription and Translation. While studying the unit on Replication, students would also appreciate how various kinds of errors can be introduced and if not removed may manifest themselves as mutations.
- The course would help them understand established repair mechanisms to take care of these mutations. Hand-in-hand and related practical knowledge would help students build their foundation for future courses like Medical Biotechnology and Genome Organization and Function.
- Students would appreciate the recent advances in molecular biology that have led to the completion of genomic projects that are changing the face of modern biology, especially in areas of medicine, agriculture and biotechnology. Research in this field has also helped in understanding the molecular basis of illnesses and use of genetic manipulation in biotechnology to make valuable products including blood clotting factors, insulin and vaccines.

SYLLABUS OF BIOMED-DSC-11

Unit-I: The Replication of DNA in Prokaryotes and Eukaryotes (14 hrs)

An introduction to chemistry of DNA synthesis. Enzyme and proteins involved in DNA replication– helicase, topoisomerases, DNA polymerases, DNA ligase, primase, RNaseH, telomerase, sliding clamp, sliding clamp loader and SSBs. Mechanism of action of DNA polymerase, DNA transactions during replication-bidirectional replication, semi-conservative, discontinuous. Mechanics at the DNA replication fork: RNA priming, initiation and termination of DNA replication (comparing prokaryotes with eukaryotes), regulation of bacterial DNA replication, replicating the 5' end of linear chromosome, replication coupled to chromatin synthesis in eukaryotes. Various models of DNA replication including Trombone model, D-loop (mitochondrial), Theta mode of replication, Rolling circle model, replication of linear ds-DNA.

Unit-II: The Mutability and Repair of DNA (6 hrs)

Replication Errors (transitions, transversion and thymine dimer), DNA Damage (deamination, depurination and dimerization). DNA repair: Direct repair, Mismatch repair, Excision Repair, Photo reactivation, Recombination Repair, SOS response.

Unit-III: Information Transfer–I: Mechanism of Transcription. (8 hrs)

Basic transcription apparatus. Transcription in Prokaryotes: Initiation, elongation and termination of transcription, Promoter sequences and concept of abortive initiation. Transcription in Eukaryotes: Types of RNA polymerases, RNA polymerase II, Promoters, TBP and other transcription factors. Transcription by RNA polymerase I and III. Inhibitors of transcription- rifampicin and- amanitin.

Unit-IV: Post-Transcriptional Modifications (8 hrs)

Split Genes, Concept of introns and exons, RNA splicing pathways: Spliceosomes and Self splicing introns (Group I and Group II introns), Ribozymes, Variants of splicing: alternative splicing, exon shuffling and RNA editing, Mutually exclusive splicing (example Drosophila Dscam gene), Mechanism determining the sex of Drosophila.

Unit-V: Information Transfer-II: Mechanism of Translation (9 hrs)

Features of genetic code and exceptions in some systems. Types of RNA: Messenger RNA, Ribosomal RNA and Transfer RNA, Ribosomal structure, Charging of tRNA, Amino-acyl tRNA synthetases, Proteins and factors involved in translation. Process of translation: Initiation, elongation and termination (Prokaryotes and Eukaryotes), Fidelity of translation, Translation-Coupled removal of defective mRNA. Inhibitors of protein synthesis–tetracyclins, aminoglycosides, chloramphenicol and aminoglycosides.

Practical (30 hrs)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Calculations and preparation of various stock and working solutions of Molecular Biology experiments (Number 2 to 9).
2. Isolation of genomic DNA from bacterial cells.
3. Isolation of genomic DNA from blood/tissue.
4. Fractionation of DNA by agarose gel electrophoresis.
5. To determine the lambda max for DNA and protein.
6. Quantify and analyze the purity of DNA using spectrophotometer (estimating at 260 nm, 280 nm and 320 nm).
7. Quantitative estimation of salmon sperm/calf thymus DNA using colorimetric assay using Diphenylamine reagent.
8. In vitro gene amplification method of Polymerase Chain Reaction (PCR): Primer designing and setting up of the reaction.

9. Analysis of the PCR products.

Essential readings:

- Karp, G. (2020). 9th Edition. *Cell and molecular biology: Concepts and experiments.* NewJersey, USA: Wiley Publishers, ISBN-13: 978-1119598244
- Cox, M. M. Doudna J. A. and Donnell, M. O. (2015). 2nd Edition. *Molecular biology: Principles and practice.* London, UK: W H Freeman & Co Publishers, ISBN-13: 978-1464126147
- Watson, J. D. Baker T. A. Bell, S. P. Gann, A. Levine, M. and Losick, R. (2013). 7thEdition. *Molecular Biology of the Gene.* New York, USA: Cold Spring Harbor Laboratory Press, ISBN-13: 978-0-321-76243-6.
- Green, M.R. and Sambrook, J. (2012). 4th Edition. *Molecular cloning: A laboratory manual,* New York, USA: Cold Spring Harbor Laboratory Press, ISBN-13:978-1936113422.
- Hardin, J. Bertoni, G.P. Kleinsmith, L.J. and Becker, W.M. (2008). 7thEdition. *The world of the cell.* San Francisco, USA: Benjamin Cummings Publishers, ISBN-13:978-0805393934.

Suggestive Readings

- Kornberg, A. (2005). 2nd Edition. *DNA replication.* California, USA: University Science Books, ISBN-13: 978-1891389443.

DISCIPLINE SPECIFIC CORE COURSE -12 (BIOMED-DSC-12) PHARMACOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Pharmacology BIOMED-DSC-12	4	3	-	1	XII Pass with Physics, Chem & Biology	Basic knowledge in Functioning of human body.

Learning objective

- This course is concerned with the study of drugs and how they can be used in the treatment of various diseases.
- The students will be able to learn about various formulations and administration of drugs in the body. The course provides basic mechanisms by which various drugs modify/affect physiology of the body leading to the treatment of various diseases.
- Students will also get an insight into making choice and functioning of drugs given to treat microbial infections, and various diseases due to imbalance of hormones in the body.

Learning outcomes

- Students will be familiarized with the naming and formulation of drugs; routes of drug administration and conditions under which one route is preferred over another in patients; various macromolecular targets (receptors, enzymes, etc.) of drugs in the body.
- They will also learn basic mechanisms of absorption, transport, excretion of drugs and effects of metabolism on drug action; basics of quantification of half-life, bio-availability and elimination of drugs in the body and factors affecting them; an insight into measurement of response, efficacy and potency of drug, and factors affecting action of the drugs.
- Students will also be imparted knowledge of the classification, mechanism of action, uses and contraindication of various classes of drugs. Assessment of the choice of antimicrobial drugs; problems arising from indiscriminate/inadequate use of antimicrobial drugs. Use of hormones and

hormone antagonists as drugs in endocrine system related disorders; hormone replacement therapy and its application.

SYLLABUS OF BIOMED-DSC-12

Unit-I: Introduction to pharmacology (07 hrs)

Nomenclature of drugs, various dosage forms of drugs (solid, liquid, semi-solid and inhalation forms) routes of drug administration, their advantages and disadvantages, various macromolecular targets of drugs (membrane receptor, transporters, enzymes, channels etc.).

Unit-II: Pharmacokinetics and pharmacodynamics (09 hrs)

Drug absorption, distribution, metabolism, and excretion, bio-availability, excretion and kinetics of elimination, biological half-life of drug and its significance, drug-drug interactions.

Unit-III: Mechanism of action of different classes of drugs (18 hrs)

General aspects; classification and mechanism of action of following classes of drugs along with side effects and contraindication of the drugs mentioned against each class should also be covered.

(a) General Anesthetics:	Halothane
(b) Sedatives and Hypnotics:	Diazepam
(c) Cholinergics:	Bethanechol, Rivastigmine
(d) Skeletal Muscle Relaxants:	Succinylcholine
(e) Adrenergics:	Isoprenaline, Propranolol
(f) Dopaminergics:	L-Dopa, Carbidopa
(g) Diuretics:	Furosemide
(h) Analgesics and Antipyretics:	Aspirin, Celecoxib

Unit-IV: Chemotherapy of microbial disease (05 hrs)

General aspects of anti-microbial therapy, Antibacterial (Quinolones: Ciprofloxacin).

Unit-V: Hormones and hormone antagonists (06 hrs)

Brief introduction to hormones; insulin and oral hypoglycemic agent (tolbutamide, metformin), HRT, estrogen and progestins (progesterone, hydroxylprogesterone caproate).

Practical (30 hrs)

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Handling of laboratory animals.
2. Routes of drug administration (Oral, I.M.)
3. To study the presence of acetaminophen in given sample.
4. To study the stages of general anesthesia.
5. To determine partition coefficient of general anesthetics.
6. Effect of analgesic (Tail-flick test).
7. Anti-anxiety effect of Valium (Plus maze test).
8. Fixing of organ bath and kymograph.
9. To record CRC of acetylcholine using guinea pig ileum/ rat intestine.
10. Determination of dose ratio.
11. Study of competitive antagonism using acetylcholine and atropine.

Essential reading

- Kulkarni, S.K. (2014). 4th Edition, Reprint. *Handbook of Experimental Pharmacology*, Vallabh Prakashan, India, ISBN-13: 978-8185731766.
- Tripathi, K.D. (2018). 8th Edition. *Essentials of Medical Pharmacology*. Jaypee Brothers, India, ISBN-13: **.9352704996-978**

Suggestive readings

- Ritter, J.M., Flower, R., Henderson, G., *et al.* (2019). 9th Edition (International). *Rang and Dale's Pharmacology.* Relx India Pvt. Ltd, ISBN-13: 978-0702074479.
- **Katzung, B. G.**, (2021) Basic and Clinical Pharmacology, 15th Edition, McGraw-Hill Education, ISBN: 978-1260452310

Pool of DSEs

DISCIPLINE SPECIFIC ELECTIVE COURSE– 04 (BIOMED-DSE-04) MEDICAL BIOCHEMISTRY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the Course	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Medical Biochemistry BIOMED-DSE-04	4	3	-	1	XII Pass with Physics, Chemistry & biology	Basic knowledge of biology	Biomedical Science

Learning objectives

The Learning objectives of this course are as follows:

- The objective of this course is to educate students on the clinical significance of Biochemistry. Students would learn the principle and applications of the diagnostic enzymology, interplay of hormones in the metabolism and details of various biomolecules of diagnostic significance.
- These topics are incorporated in the course to impart relevant information on clinical biochemistry. This course will also focus on the contemporary methods and practical approaches that are used in the clinical laboratories for the investigation of the parameters to ascertain normal and diseased state.

Learning outcomes

The Learning outcomes of this course are as follows:

- Having successfully completed this course, students shall be able to learn and appreciate:
- To integrate the biochemical pathways of different biomolecules; the point of divergence and convergence and will have a comprehensive overview of the metabolic and hormonal regulation of pathways and cycles.
- Students will understand how disruptions in intermediary metabolism can lead to manifestations of diseases. Additionally, hormonal actions in maintaining body mass shall be understood and factors leading to disorders such as obesity and diabetes will also be learnt.

- The diagnostic significance of enzymes and isoenzymes as diagnostic markers in clinical tests. They will learn to assess how biochemical tools accomplish diagnostic and therapeutic interventions on metabolic and genetic disorders. They will also learn to correlate the tissue/organ-specific metabolic indicators with the physiological and clinical state of a patient.
- Students would be able to gain knowledge about several bimolecular conjugates, their structural complexities, physiological significance and clinical correlations, especially the disorders related to lipid metabolism.
- Students will learn about recommended daily allowance for vitamins, their role as dietary precursors and clinical significance of deficiency diseases.
- With the help of diagnostic kits that are used in clinical laboratories students will learn to perform qualitative and quantitative analyses of samples. Through the presentations made on the known case studies, students will learn how to apply the gained knowledge in diagnosis and prognosis of a disease and know the relevance of preventive measures taken in healthcare. Also, they will be introduced to quantitative analysis of biomolecules in clinical biochemistry and evaluation of relevant data.

SYLLABUS OF BIOMED-DSE-04

Unit I: Introduction to Medical Biochemistry with an Overview of Integrative Metabolism (12 hrs)

Basic Concepts and Scope of Medical Biochemistry.

Local and global regulation in tissue specific metabolism. Interplay of insulin and glucagon hormones. Integration of various metabolic pathways of proteins, lipids and carbohydrates. Obesity, role of leptin, ghrelin and adiponectin in regulation of body mass, hunger and satiety.

Unit II: Enzymes - Distribution and Diagnostic Significance (12 hrs)

Properties of enzymes used in diagnosis. Factors affecting levels of diagnostic enzymes in blood and the selection of a test. Clinical significance of diagnostically important enzymes: Creatine kinase, Lactate dehydrogenase, alanine- and aspartate aminotransferases, with a detailed account of the biochemical reactions catalyzed by these enzymes and of their clinical assays. Kinetic assay and end point assay for the enzymes. Isoenzymes: types of isoenzymes, allozymes, hybrid isoenzymes, isoforms,their tissue distribution, clinical and diagnostic significance.

Unit III: Structural Complexities and Diseases Associated with Carbohydrates and Lipids (14 hrs)

Carbohydrates: Sugars as information molecules. Detailed account on Lectins: their role in physiological functions and their potential as drug targets in various infectious diseases. Dietary fibres

Lipids: Types of Lipoproteins (chylomicrons, VLDL, LDL, HDL). Disorders associated with lipid metabolism (hyperlipidemia). Prostaglandins: classification, biosynthesis, role of COX-1, COX-2, NSAIDS in synthesis, functions.

Steroids: Cholesterol- biosynthesis and regulation, inhibitors of cholesterol biosynthesis (Statins - structure and biochemical basis).

Unit IV: Vitamins (7 hrs)

Definition, classification, functions, recommended dietary allowances, and dietary precursors. Diseases (1 each, due to deficiency of water-soluble and fat-soluble vitamins): symptoms and clinical significance

Practical (30 Hrs)

(Wherever wet-lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs, etc.)

1. Virtual demonstration of preparation of serum or plasma from whole blood.
2. Quantitative determination of the following (any 4):
    i) SGPT/SGOT
    ii) Albumin/Total protein and A:G ratio
    iii) Urea
    iv) Uric acid
    v) Total Cholesterol, HDL, LDL
    vi) Triglycerides
3. Interpretation of case studies (any 3)
4. Analysis of a given Diagnostic Test Report for KFT/LFT/Myocardial Infarction.
5. Profiling of Iron and Vitamin D/B12 deficiency in Indian Population, using recent published data.

Essential Reading:

- Nelson, D.L. and Cox, M.M. (2021). *Lehninger: Principles of Biochemistry* (8th ed.). Macmillan. ISBN: 9781319322328

- Burtis, C.A., Bruns, D.E.,Sawyer, B.G, Tietz,NW (2015). *Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics*. United States Of America:WB Saunders Company, ISBN: 9781455741656
- Chatterjee & Shinde (2012). *Textbook of Medical Biochemistry* (8^{th} ed). New Delhi, India: Jaypee Publications ISBN: 978-93-5025-484-4
- Literature provided by Diagnostic Kit's manufacturer.

Suggestive reading

- Murray, R. Bender, D.Botham, M.K.Kennelly, P.J.Rodwell, V.Weil, P.A. (2018). *Harpers Illustrated Biochemistry*; New Delhi, India: McGraw-Hill Medical.
- Devlin, T.M. (2011). *Textbook of Biochemistry with Clinical Correlations*. New Jersey, United States of America: John Wiley & Sons, Inc.

DISCIPLINE SPECIFIC ELECTIVE COURSE –5 (BIOMED-DSE-05) INDUSTRIAL MICROBIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/Practice		
Industrial Microbiology BIOMED-DSE-05	4	3	-	1	XII Pass with Physics, Chemistry & biology	Basic knowledge of biology

Learning objectives

- The Industrial Microbiology course has been formulated to train students on how microbiological techniques are carried out in industrial practices.
- Students will be able to learn usage of microorganism for industrial applications.
- This course will concentrate on experimental practice and their theoretical aspects. Study of this course will develop trained manpower ready for industry and bridge the huge gap that exists between knowledge based conventional education and market demands.
- This would further help inculcate sense of job responsibilities, while maintaining social and environment awareness.

- Students would eventually build-up a progressive and successful career in industries with a biotechnological perspective.

Learning outcomes

- The course on Industrial Microbiology starts with the fundamental basics and scope of industrial microbiology. Students would learn the requirements for setting up an Industrial Microbiological unit along with the kind of microbial products that can be made available.
- The course would help the students to explore the benefits of microbial kingdom.
- Students would also understand the process of selection of potent strains suitable for industrial application and use of mutants/genetically modified organism for this purpose. Methods associated with usage and selection of appropriate fermentation process will enhance the learning of students enable them to think in new horizons.
- Selection of appropriate nutrient for the multiplication of microorganism plays a significant role at industrial level. Through understanding of the current scenario might help them setting their own ventures.
- Students would be given a glimpse of extraction of fermentation products and maintenance of sterility in fermenters. Different types of nutritive products/beverages such as beers, wines, spirits, bread, single cell proteins can be obtained using fermenters.
- At the end of syllabus students would learn the process of waste water treatment by municipal corporations.

SYLLABUS OF BIOMED-DSE-05

Unit I: Scope of Industrial Microbiology (6 hrs)

Scope of Industrial Microbiology; Industrial microbiology in comparison to Chemical/any other industry; emphasis on functioning of fermentation industry; examples of products and microbes; Industrial Microbiology and Biotechnology; History (An Art from the Past, a Skill for the Future); Obsolescence in Industrial Microbiology.

Organizational set-up in an industrial microbiology establishment: Upstream processing (USP) and downstream processing (DSP); unit downstream processing. Bioprocess: introduction, advantages and limitations. Industrial fermentation products and their producer microorganisms.

Unit II: Industrial Microorganisms (8 hrs)

Taxonomic diversity of industrially useful bacteria and Fungi: Brief Discussion, general feature and taxonomic position; Bacterial genomes and genomics of bacterial plasmids; Useful Characteristics in microbes used in Industrial Microbiology and Biotechnology; Isolation of suitable producer microorganisms from environment.

Concept of Microorganisms classified as Generally Regarded As Safe (GRAS); Culture Collections of industrial microorganisms; Industrial producer strains and strain improvement: Outline and importance of the process; Use of mutants / Genetically Modified Microorganisms (GMM) as against Wild type isolates for production; ethical issues related to release of GMM in the environment. Aseptic and non-aseptic fermentations; Fermentation types according to organization of biological system: Suspended and support culture; Screening for productive strains. Good manufacturing processes.

Unit III: Industrial Media and the Nutrition of Industrial Organisms (6 hrs)

Basic Nutrient Requirements of Industrial Media; Criteria for the Choice of Raw Materials Used in Industrial Media; Raw Materials Used in Compounding Industrial Media; Potential Sources of Components of Industrial Media; Use of Plant Waste Materials in Industrial Microbiology: Saccharification of Polysaccharides, Standard microbes used in Industry, like useful *E.coli* and *Pichia.*

Unit IV: Fermenters and its Operation (7 hrs)

Definition of a Fermenter; Aerated Stirred Tank Batch Fermenter; Temperature control in a fermenter; Foam production and control; Process control in a fermenter; Anaerobic Batch Fermenters; *Continuous fermentations;* Design of New Fermenters on the Basis of Physiology of the Organisms; Place of the Pilot Plant; Inoculum Preparation; Surface or Solid State Fermenters; Extraction of Fermentation Products; Maintenance of sterility in Fermenters

Unit V: Production of fermented foods and Metabolites (13 hrs)

Single Cell Proteins and its nutrition value; Yeast Production; Other fermented foods – from bread, corn etc; Production of Beers: Barley and Sorghum Beers; Production of wines and spirits: Grape wines; Palm wines and Distilled Alcoholic (or Spirit) Beverages; Production and processing of vinegar. Production of

Organic Acids and Industrial Alcohols; Amino Acids; Biocatalysts; Microbial Fertilizers; Microbial Insecticides; Antibiotics and Anti-Tumor Agents; Ergot Alkaloids; Microbial Transformation and Steroids and Sterols; Vaccines; Microbial Products with Bioactive properties.

Unit VI: Treatment of wastes in industries (5 hrs)

Methods for determination of organic matter content in Waste Waters – Dissolved oxygen, Biological oxygen demand, Permanganate value (PV) test, Chemical oxygen demand, Total organic carbon, Total suspended solids, Volatile suspended solids; Wastes from Major Industries; Systems for the Treatment of Wastes; Treatment of the Sludge; Waste Water Disposal in the Pharmaceutical Industry. Municipal waste water treatment plant, Microbial degradation of pollutants (Bioremediation), Recovery of resources from waste using microbes (biomining/metal recovery).

Practical (30 hrs)

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Field trip to any industrial setup / research organization for demonstration of fermenters.
2. Antibiotic/anticancer drugs production using Streptomyces species.
3. Replicate the classic experiment of Sir Alexander Fleming experiment for the production of penicillin.
4. Fermentation of sugarcane syrup using yeast and detection of alcohol percentage.
5. Microbial biomass production: manufacturing of baker's yeast.
6. Mushroom cultivation strategies.
7. Maintenance of starter culture for probiotics.
8. Demonstration of production/extraction of microbial production.
9. Commercial microbial production.

Essential Readings

- Willey, J., Sherwood, L., and Woolverton, C.J. (2019). 11th Edition. Prescott's microbiology. New York, USA: McGraw-Hill Education. ISBN-13: 1260211887-978 .
- Tortora, G.J., Funke, B.R., Case C.L. Weber, D. and Bair, W. (2018). 13th Edition. Microbiology: An introduction. Addison-Wesley, ISBN-13 : 978-0134605180.

- Cappuccino, J.G. and Welsh, C. T. (2017). 11th Edition. Microbiology: A laboratory manual. Pearson Publishers. ISBN-13: 1292175782-978.

Suggestive Readings

- Tille, P. (2013). 13th Edition. Bailey & Scott's diagnostic microbiology. Elsevier’s Publishers. ISBN-13 : 978-0323681056
- Pelczar, M.J (2001). 5th Edition. Microbiology. New York, USA: McGraw Hill International. ISBN-13: 9780074623206.

DISCIPLINE SPECIFIC ELECTIVE -6 (BIOMED-DSE-06) ENVIRONMENT SUSTAINABILITY AND BIOMEDICAL WASTE MANAGEMENT

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Environment Sustainability And Biomedical Waste Management BIOMED-DSE-06	4	3	-	1	XII Passed	Basic knowledge of biology

Learning objectives

The Learning objectives of this course are as follows:

- To promote awareness among students about the importance of environment and its sustainable usage and development
- To highlight the components affecting environment and factors responsible for deterioration of environment
- To familiarize with the techniques available for waste management, use of refuse/ reduce/re-use/ recover/re-cycle of substances toxic for environment

Learning outcomes

Having successfully completed this course, students shall be able to learn and appreciate:

- Surroundings and environment, renewable/non-renewable natural resources and their exploitation. Sensitizing about environmental crisis can promote them to for search alternatives to reduce our dependence of non-renewable natural resources and their usage.
- Studies on pollution and deforestation will help them to understand their impact on environment and human health. Conservation of forests and recycling policies will promote social awareness about sustainable development.
- Learning about various methods of sustainable development is an important for skill development in students so that they can design better strategies to protect our environment.
- Generation of biomedical waste is alarmingly increasing but the awareness of appropriate waste disposal methods is completely lacking. Development of new methods for waste management and strategies in this area will help them to reduce and segregate waste at point source.
- At the end of this course, students will be able to understand the severity of the problem and influence of biohazards on human health

SYLLABUS OF BIOMED-DSE-06

Unit I: Environment and Environmental Crisis (08 hrs)

Function of environment, resources (biotic and abiotic), renewable resources (air, water, land) and non-renewable resources (fossil fuels), worldwide Environmental Crisis: Global Warming, Ozone Layer Depletion, Measures to protect environment: environmental pollution and its control measures, air pollution in metropolitan cities of India, Deforestation and conservation, steps for social awareness, Reduce, Reuse and Recycle policy for waste management, water conservation, implementation of policies and programmes for environment sensitization, Environmental tribulations in India: Environmental degradation, Indian government proposals and plans to protect environmental degradation

Unit II: Role of green technologies in Sustainable development (14 hrs)

- Definition and aspects, requirements, strategies and way for sustainable development , Role of education for sustainable development (ESD); Management of resources for human consumption and its impacts assessment, Influence of biodiversity on ecosystem services, Land use changes for agriculture and food, Indian government initiatives to implement sustainable development, Challenges to acquire SDGs.

- Surfacing green technologies and sustainable growth, Different aspects of sustainable development: bioprospect of plant essential oils for medicinal uses-revival of Indian ancient practice; Nanotechnology: potential for environmental sustainability, Role of photo-catalyst in environmental remediation, Applications and future prospective of biopolymers in industries; Green and self-sustainable buildings: Opportunities and challenges

Unit III: Measures for Sustainable development (09 hrs)

Phytoremediation of chemopollutants, bioconversion of industrial wastes into value-added polyhydroxyalkanoate (eg sugar and oils), Role of fungal and bacterial resources in heavy metal/radioactive waste material contaminated soil remediation and ecological restoration, xenobiotics bioremediation using fungi, Impact of pesticides usage in agricultural practices on microbial communities and soil bioprocesses: a biochemical, physiological, and molecular perception; Possibilities of biofuel production from microalgae as renewable energy source for environmental sustainability, integrated algal industrial waste treatment and bioenergy generation

Unit IV: Biomedical waste management (07 hrs)

Definition and classification of biomedical waste, Infectious, non-infectious and chemical waste;
Waste management: designation of waste, segregation, packaging and transportation.
Treatment: steam sterilization, chemical disinfection, incineration, emerging treatment technologies, treated waste disposal, regulatory and advisory considerations, Training of supportive staff

Unit V: Health and safety of workers in hazardous environment (07 hrs)

Exposure of workers at hazardous waste sites: chemical exposure, explosion and fire, ionizing radiation, biologic hazards, oxygen deficiency, heat stress, blood borne pathogens, safety hazards, electrical hazards, noise hazards, cold exposure, other physical hazards, hazardous waste operations and emergency response

Practical (30 hrs)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Document the Biological Wealth (flora and fauna) of your campus.
2. Calculate the water footprint of your organization.
3. Examine the current status of organization for waste management. Develop guidelines to reduce waste by improved methods of handling and disposing of wastes.
4. Plan guidelines for the safety of workers working at hazardous waste sites.
5. A case study on “Make sustainability more than just the right thing to Do”
6. A case study on handling and disposal of wastes.
7. Develop green design of organization to maintain and enrich the biological wealth.
8. Understandings of energy missions and follow up for classroom energy audit.
9. Prepare a questionnaire to asses knowledge, attitude and practices among students about Sustainable Development
10. Prepare a poster on Bio-augmentation and Bio-stimulation**.**
11. Make a poster on success stories of environment polices and movements that have reduced pollution or reversed diminishing populations of unique species.
12. Determine your carbon foot printing.

Essential readings

- Sangeetha, J; Thangadurai, D; David, M and Abdullah, M.A. (2021) 1st Edition. Environmental Biotechnology: Biodegradation, Bioremediation, and Bioconversion of Xenobiotics for Sustainable Development. Edited by. Apple Academic Press Inc, 9 Spinnaker Way, Waretown, NJ 08758, USA. International Standard Book Number-13: 978-1771883627.
- Fulekar, M.H.; Pathak, B; Kale, R.K. (2014) Edition 2014th Environment and Sustainable Development. Publisher-Springer Nature ISBN: 978-8132211655
- William C. Blackman, Jr (2001) Basic hazardous waste management.. Third Edition, Lewis Publishers, Boca Raton London New York Washington, D.C. ISBN 1-56670-533-9 (alk. paper)

Suggestive readings:

- Tweedy, James T., Healthcare hazard control and safety management-CRC Press_Taylor and Francis (2014).

SEMESTER-V
BIOMEDICAL SCIENCE

DISCIPLINE SPECIFIC CORE COURSE –13 (BIOMED-DSC-13) GENOME ORGANIZATION AND FUNCTION (GOF)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical /Practice		
Genome Organization and Function BIOMED-DSC-13	4	3	-	1	XII Pass with Physics, Chemistry & biology	Basic knowledge of biology

Learning objectives

- The course on Genome Organization and Function (GOF) will review the basic concepts of organization and architecture of human genome.
- This course would equip the students with intriguing concepts of genome packing within the nucleus, the regulatory strategies either at transcriptional or translational level, gene silencing, RNAi and mechanisms of regulatory effects of non-coding RNA.
- The objective is to remain competitive and relevant in international sense by offering high quality academic programs and research activities.

Learning outcomes

- Students will acquire basic concepts of genome, its organization and maintenance, packaging of DNA into chromosome structure, changes in histone and chromosome remodeling proteins.
- Students will learn the concept of regulatory mechanisms governing over-expression and under-expression of genes. They will understand transcriptional and translational control in prokaryotes and in eukaryotes.
- Students will also learn about post-translational control-mRNA decay and Proteolysis. Students will understand regulatory RNA in prokaryotes and in eukaryotes (sRNA, riboswitches,

CRISPER- Cas system, RNA interference, miRNA and siRNA, Piwi interacting RNA) and Regulatory RNA in X-inactivation.

SYLLABUS OF BIOMED-DSC- 13

Unit-I: Organization of Human Genome (7 hrs)

General features: Genome size, gene density and diversity. Types of repetitive DNA. Nucleosomes: Basic unit of DNA condensation, packaging of DNA in to chromosome structure, nucleosome assembly. Protein and RNA encoding genes. Gene-families and super families. Processed and non-processed Pseudogenes.

Unit II: Gene Regulation at DNA level (6 hrs)

Prokaryotic gene regulation- Histone like proteins, overlapping genes.

Eukaryotic gene regulation: Genomic control – gene amplification and deletions, DNA rearrangements, chromosome puffs, DNA methylation, CpG islands. Changes in histone and chromosome remodeling proteins-HAT and HDAC, Chromodomain and Bromodomain proteins, nucleosome modifications and nucleosomes positioning.

Unit-III: Transcriptional Regulation in Prokaryotes (6 hrs)

Principles of transcriptional regulation. Activators and Repressors and their mechanism of working. Bacterial gene regulation with reference to Operons- Lactose, Tryptophan and Arabinose operon. Combinatorial control. Role of sigma factors in gene expression.

Unit-IV: Transcriptional Regulation in Eukaryotes (10 hrs)

Difference between gene regulation in Prokaryotes and Eukaryotes. Cis-acting regulatory sequences-Promoters, Enhancers, Insulators, Boundary elements. Regulatory proteins-Activators, Repressors and Co-activators, their structure and mechanism of working, Structural difference among the different DNA binding domains, Regulation of LCR, Signal integration and Combinatorial control, Signal transduction pathways- MAP kinase and STAT pathways. Techniques for studying DNA-Protein interaction: EMSA, DNA foot printing, ChIP assay.

Unit-V: Regulatory RNAs **(6 hrs)**

Regulation by RNAs in Prokaryotes: sRNA (6S RNA, RybB, DsrA, RprA, OxyS), Riboswitches, Attenuation in trp operon. Structure, Origin and Functioning of CRISPR-Cas system. Regulation by RNAs in Eukaryotes: RNA interference-need and mechanism. Therapeutic uses of RNAi. RNA Induced silencing complex (RISC) and Argonaute (AGO). miRNA- structure, origin and working. siRNA-structure, origin and working. Piwi-interacting RNA- structure, origin and working. Regulatory RNA and X-inactivation: long non-coding RNA. Mechanism of X-inactivation.

Unit-VI: Translational and Post-Translational Regulation **(10 hrs)**

Rationale of gene regulation at translation level. Regulation of Prokaryotic translation-protein and RNA bonding to RBS, Ribosomal proteins as translational repressor, Tm RNA. Regulation of Eukaryotic translation- Global regulation and Gene specific regulation. Regulation of Oscar protein by Cup protein in Drosophila, Regulation of Ferritin in Humans, Regulation of Gcn4 in yeast, Eukaryotic mRNA structure and stability. mRNA decay pathway in Eukaryotic cells: De-adenylation dependent pathway and De-adenylation independent pathways- Endoribonucleolytic decay, Nonsense and Nonstop mediated decay, No-Go decay and RNAi dependent pathway of mRNA decay. Proteolysis in Prokaryotes and Eukaryotes, Lysosome and Proteasome mediated protein decay, Ubiquitin-Proteasome pathway.

Practical **(30 hrs)**

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Preparation of various stock solutions for mentioned experiments.
2. Isolate plasmid/ genomic DNA of the sample provided.
3. Comparative analysis of genomic DNA and plasmid DNA by restriction enzyme digestion and estimation of size of a DNA fragment after electrophoresis using DNA markers.
4. Quantification of unknown DNA using Lambda-Hind III marker.
5. Study transfer of DNA through Southern Blotting.
6. Perform hybridization of DNA using Southern Blot.
8. Separation of proteins using SDS PAGE.
9. Perform Western hybridization.
7. Bioinformatic analysis of Prokaryotic gene.
8. Bioinformatic analysis of Eukaryotic gene.

Essential Readings

- Klug, W. S. Cummings, M. R. Spencer, C. A. and Palladino, M. A. Killian, D. (2019*)*. 12th Edition*. Concepts of genetics.* San Francisco, USA: Benjamin Cummings Publishers. ISBN-13:978-0134604718
- Strachan, T. and Read, A. (2018). 5th Edition. *Human molecular genetics*. Florida, USA: CRC Press, Garland Science. ISBN: 978-0815345893.
- Cox, M. M. Doudna J. A. and Donnell, M. O. (2015). 2nd Edition. *Molecular biology: Principles and practice.* London, UK: W H Freeman & Co Publishers, ISBN-13: 978-1464126147
- Watson, J.D. Baker T.A. Bell, S.P. Gann, A. Levine, M. and Losick, R. (2013). 7th Edition. *Molecular biology of the gene.* New York, USA: Cold Spring Harbor Laboratory Press.ISBN-13:9780321762436.
- Snustad, D. P. and Simmons, M. J. (2011). 6th Edition*. Principles of genetics.* New York, USA: John Wiley and Sons.ISBN-13: 978-0470903599

Suggestive Readings

- Karp, G. (2020). 9th Edition. *Cell and molecular biology: Concepts and experiments.* NewJersey, USA: Wiley Publishers, ISBN-13: 978-1119598244
- Cooper, G.M. and Hausman, R.E.(2013). 6th Edition. *The cell: A molecular approach.* Massachusetts, USA: Sinauer Associates. ISBN-13:978-1605351551.
- Green M.R. and Sambrook J. (2012). 4thEdition, (three-volume set). *Molecular cloning: A laboratory manual.* Cold Spring Harbor Laboratory Press. ISBN-13: 978-1936113422.
- Snustad, D. P. and Simmons, M. J. (2011). 6th Edition*. Principles of genetics.* New York, USA: John Wiley and Sons. ISBN-13: 978-0470903599.
- Hardin ,J. Bertoni, G. P. Kleinsmith, L.J. and Becker, W.M.(2008).7thEdition. *The world of the cell.* San Francisco, USA: Benjamin Cummings Publishers. ISBN-13:978-0805393934.
- Kornberg, A. (2005). 2nd Edition. *DNA replication.* California, USA: University Science Books. ISBN-13: 9781891389443.
- Cantor, C. R. and Smith, C. L. (1999). 1st Edition. *Genomics: The Science and technology behind the human genome project.* NewYork, USA: JohnWiley and Sons. ISBN-13:978-0471599081.

DISCIPLINE SPECIFIC CORE COURSE –14 (BIOMED-DSC-14) MEDICAL BIOTECHNOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical / Practice		
Medical Biotechnology BIOMED-DSC-14	4	3	-	1	XII Pass with Physics, Chemistry & biology	Basic knowledge of biology

Learning objectives

- The objective of this course is to enable the students to comprehend the concepts of recombinant DNA technology and apply the gained knowledge towards cloning and expression of genes and purification of the recombinant proteins.
- In the process, students would get a grasp on the cutting-edge technologies used in the analysis of nucleic acids and expressed proteins. The course aims to give students training in modern molecular techniques and help them make a connection between biological concepts and the technologies developed for various applications in biotechnology.
- The course finally aims to augment students' understanding of the role biotechnology plays/can play in various aspects of human medicine and provide them the platform to appreciate the drivers of emerging innovations in medical biotechnology along with biosafety and ethical concerns.

Learning outcomes

- Students will learn the contemporary techniques being applied in the field of medical biotechnology which include PCR, Gene Cloning, Gel electrophoresis etc.
- Students will gain a comprehensive understanding of DNA manipulation techniques and how to create recombinant DNA molecules by making a suitable choice of vectors and expression hosts.
- An in-depth understanding of gene cloning, expression in prokaryotic and eukaryotic systems and on the production of recombinant proteins shall prepare students to apply the gained knowledge on different organisms.

- Having grasped the fundamentals of recombinant DNA technology, its robust potential and the limitations & challenges, students shall discern the applications of biotechnology in human medicine. Their gained knowledge shall be imbued with a deeper understanding of the safety and limitations of molecular tools used in the diagnostics of infectious diseases, production of biopharmaceuticals and gene therapy.

SYLLABUS OF BIOMED-DSC-14

Unit I: Introduction to Recombinant DNA Technology and its applications in Medical Biotechnology

(13 hrs)

Brief history and scope of molecular biotechnology, concept of manipulation of DNA, cloning vectors and gene cloning. Restriction and modification system: Type I-IV restriction endonucleases, nomenclature and sequence recognition, isochizomers, blunt end and sticky ends, restriction mapping. Joining of DNA molecules: role of DNA ligase enzymes, adaptors, linkers, homopolymer tailing.
Cloning vectors: bacterial plasmids (T-vector, pUC vector), Lambda phage-derived vectors (replacement and insertion vectors), Cosmids, *in vitro* packaging. Gene cloning: Blunt end and directional.

Unit II: Expression of cloned genes in prokaryotes (13hrs)

Prokaryotic expression vector (pET vector). Bacterial transformation (*E.coli*): Preparation of competent cells ($CaCl_2$ method), selection of the transformants (antibiotic-resistance) and screening (blue/white & by colony PCR). Challenges in the expression of foreign proteins in a heterologous host, Factors affecting the expression: Promoters, Codon usage, Plasmid copy number. Fusion proteins and tagged protein cleavage system. Gene Probe preparation, Use of enzymatic and chemiluminescent methods for the detection of proteins.

Unit III: Cloning and expression in a eukaryotic system (09hrs)

Concept of auxotrophic mutants of yeast (eg. *Saccharomyces cerevisiae*) as cloning host. Cloning vectors (yeast Integrative (yIP), Replicative (yRP) and Episomal (yEP) plasmid, YAC), Shuttle vectors. Expression in eukaryotic cells, screening and selection of recombinants. cDNA cloning.

Unit IV: Applications of Medical Biotechnology (10hrs)

(a) Production of recombinant biopharmaceuticals: Insulin and Factor VIII.

(b) Gene Therapy: Strategies and limitations, Somatic and germline gene therapy, Vectors used in gene therapy (viral and non-viral) and their comparison.

(c) Polymerase chain reaction (PCR): Principle and applications. Importance of RT PCR in diagnosis of infectious diseases.

(d) Biosafety and ethical concerns in medical biotechnology.

Practical **(30 hrs)**

The below listed practicals are based on a guided project: 'PCR-based gene cloning' where students need to work in a group (4-6 students) to perform *in vivo* gene cloning. For this, any prokaryotic gene of interest may be chosen.

1. Plasmid DNA isolation
2. Designing of gene-specific primers
3. PCR amplification of the desired gene
4. Agarose gel analysis of plasmid DNA and PCR product(s).
5. Restriction digestion of plasmid DNA (vector) and PCR product (insert)
6. Ligation of the insert and vector using T4 DNA ligase
7. Preparation of competent cells (*E.coli*) using the calcium chloride method
8. Transformation of competent bacterial cells with ligation mixture along with suitable controls.
9. Screening of transformants by blue/white selection OR by colony PCR.

Essential Readings

- Bernard, R. G. Jack, J. P. and Cheryl, I. P. (2022). 6th Edition. *Molecular biotechnology: Principles and applications of recombinant DNA.*USA: ASM press, ISBN-978-1-683-6736-8
- Brown, T. A. (2016). 7th Edition. *Gene cloning and DNA analysis: An introduction.* NewYork, USA: John Wiley and Sons, ISBN-978-1-119-07256-0.
- Primrose, S. B. and Twyman, R. B. (2006). 7th Edition. *Principles of gene manipulation and genomics.* Oxford, UK: Blackwell Scientific Publishers. ISBN:978-1405135443.

Suggestive Readings

- Karp, G. (2020). 9th Edition. *Cell and molecular biology: Concepts and experiments.* NewJersey, USA: Wiley Publishers, ISBN-13: 978-1119598244
- Green, M.R. and Sambrook, J.(2012). 4th Edition, (three-volume set). Molecular cloning: A laboratory manual. New York, USA: Cold Spring Harbor Laboratory Press ISBN-13:978-1936113422.

DISCIPLINE SPECIFIC CORE COURSE –15 (BIOMED-DSC-15) HUMAN PATHOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical		
Human Pathology BIOMED-DSC-15	4	3	-	1	XII Pass with Physics, Chemistry & biology	Basic knowledge of biology

Learning objectives

The Learning objectives of this course are as follows:

- The course of Human Pathology will build upon the existing knowledge that the students have gained in physiology, cell biology, immunology to help them understand how alteration of normal state takes place and diseases develop. The curriculum is a systematic presentation of the various internal and external stimuli that initiate pathogenesis of diseases.
- Topics like cellular adaptations, inflammation, repair and hemodynamic disorders would assist students for better understanding of the subject.
- Study of neoplasia and a few infectious and non-infectious diseases would help in understanding and integration of all concepts.

Learning outcomes

Having successfully completed this course, students shall be able to learn and appreciate:

- Basics of disease in human body
- Adaptation of the human body under stress and injury
- Repair and healing of wounds
- Importance of early detection, diagnosis and treatment in any disease
- Prevention is better than cure and one needs to follow the discipline and healthy lifestyle

SYLLABUS OF BIOMED-DSC-15

Unit-I: Introduction, Cellular Adaptations, Cell Injury and Cell responses (7 hrs)

History of pathology with respect to medical science, basic definitions and familiarization with the common terms used in pathology, Causes and mechanisms of cell injury: reversible and irreversible injury, Overview of pathogenesis (salient steps) and Cellular responses: (subcellular, intracellular and intercellular response, Hyperplasia, Metaplasia, Hypertrophy, Atrophy, dysplasia, Necrosis, Apoptosis) with one example each.

Unit-II: Inflammation and its significance in Diseases (7 hrs)

Hallmarks of Inflammation and why inflammation ensues with suitable examples. General features of acute and chronic inflammation: Vascular changes, cellular events, termination of acute inflammatory response, Molecular mediators of inflammation, morphological effects and outcome of acute inflammation. Systemic effects of inflammation

Unit-III: Hemodynamic Pathology (7 hrs)

Edema, hyperaemia, congestion, hemorrhage, haemostasis and thrombosis, Embolism, Infarction, shock and hypertension.

Unit-IV: Tissue Repair and Remodeling (8 hrs)

Control of cell proliferation, maintenance of cellularity and differentiation, mechanism of tissue and organ regeneration. Wound healing by repair (first and second intention), scar formation and fibrosis, role of extracellular matrix. Angiogenesis and pathological aspects of remodeling (eg Atherosclerosis).

Unit-V: Tumor Pathology and Pathogenesis (8 hrs)

Definitions, nomenclature, characteristics of benign and malignant neoplasms, biology of tumor growth, mechanism of tumor invasion, metastasis cancer progression. Overview of genetic changes in transformed cells and cancer stem cells.

Unit-VI: Pathophysiology of Diseases (8 hrs)

Etiopathogenesis of following diseases: Communicable (Tuberculosis), Non-communicable (CAD, Myocardial Infarction and Asthma, Diabetes).

Practical **(30 hrs)**

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.- minimum 8 practicals)

1. Urine Analysis: Gross examination of urine for colour, odor etc. Abnormal constituents like protein, ketone bodies, glucose, blood, urea (any three)
2. Histopathology Tissue Processing, embedding, sectioning. Staining and preparation of permanent histological slides.
3. Study of four distinct stages of alcoholic liver disease through permanent slide.
4. Study of histological slides showing hypertrophy, hyperplasia, dysplasia, leukemia, cirrhosis
5. Hematological assessment: Study and analysis of a blood report: CBC, KFT, LFT, lipid profile, thyroid profile.
6. Measurement of Erythrocyte Sedimentation Rate.
7. To perform Platelet count and its pathological significance
8. To perform reticulocyte count its pathological significance
9. Study of fractures
10. Diagnostic tests: Detection of various Diseases – Montoux test, CRP, VDRL, RA, Pregnancy (any two)

Essential Readings

- Kumar, V., Abbas, A.K., Aster, J.C. and Fausto, N. (2020). 10th Edition. Robbins and Cotran Pathologic basis of disease. Philadelphia, USA: Saunders Publishers. ISBN 13: 9780323531139.
- Cross, S.S. (2019). 7th Edition. Underwood's Pathology: a Clinical Approach: with STUDENT CONSULT Access ISBN-13: 978-0702072123.
- Sood, R. (2009). 6th Edition Volume 1 and 2. Medical laboratory technology methods and interpretations. India: Jaypee Brothers Medical Publishers. ISBN-13:978-8184484496. There is no recent edition but another book which i have not seen

Suggestive Readings

- Goswami, P; Kalla, A.R; Khatri, K. Dubey, A and Goswami, K. (2022) 1st Edition, Comprehensive Pathology Practical and Technical book , Scientific Publishers. ISBN: 9789392590313

  Copstead-Kirkhorn, L. C. (2021). 7th Edition. Pathophysiology. Philadelphia, USA: Saunders. ISBN: 9780323761550

Pool of DSEs

DISCIPLINE SPECIFIC ELECTIVE COURSE –(BIOMED-DSE-07) MEDICAL LABORATORY TECHNOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical /Practice		
Medical Lab Technology BIOMED-DSE-07	4	3	-	1	XII Pass with Physics, Chemistry & biology	Basic knowledge of biology

Learning objective

- The course on Medical Lab Technology would enable students to have an in-depth understanding of key concepts required in Clinical Laboratory set-ups.
- Students would be precisely trained to assist Physicians, in Laboratory set-ups and Hospitals, in handling samples, centrifuging, making slides, using specified stains etc, under proper guidance.
- After completion of the course, students would have an opportunity to work as research fellows in molecular diagnostics, molecular biotechnology companies and in research labs.

Learning outcomes

At the end of the course student would be able to:

- Develop specific laboratory skills, such as accurate pipetting, mixing, filtration, dispensing etc. using multi-step methods.
- Learn about ethics of working in biomedical labs and concerns about the medico legal aspects in Medical Laboratory Science.

- Comply with laboratory safety regulations and standards. Analyze and appreciate the quantum of biomedical waste that is generated and managed in various Labs.
- Exhibit skills essential to identify and determine blood group incompatibility. These skills would help them to analyze any mismatch during the blood transfusion reactions.

SYLLABUS FOR BIOMED-DSE-07

Unit 1: Clinical laboratory- Basic Principal and Procedure (06 hrs

Standardized clinical lab setup, Lab safety and First-aid measures, Laboratory Calculations. Definition of Biomedical Waste: Types of waste generated from Health Care Facility, Segregation, Collection, Transportation, Treatment, and Disposal (including color coding) of biomedical waste. Medical Ethics - Definition - Goal - Scope, Autonomy and informed consent - Right of patients, Obtaining an informed consent, Ethics in the profession of Medical Laboratory Science.

Unit II: Classical Instruments and Automation used in Medical Laboratory (09 hrs)

Working Principle of: Distillation setup, RO system, Weighing balance, Centrifuge, Bio safety cabinet, Spectrophotometer – Visible and UV-Visible, Water bath, Incubators, Hot Air Oven, Vortex mixer, Magnetic stirrer, Autoclave, Automation in clinical labs.

Unit-III: Clinical Biochemistry (10 hrs)

Organ Function Tests: Liver Function Tests, Renal Function Tests, Thyroid function tests and Pancreatic Function tests, Cardiac Profile, Diabetic Profile: Regulation of Blood Glucose, FBS, PP, Glucose tolerance test (GTT), Glycosylated Hemoglobin (HbA1C), Microalbuminuria etc. Gonadal Hormonal Profile: FSH, LH, Testosterone, Estradiol.

Unit-IV: Clinical Hematology (8 hrs)

Anticoagulants: Mechanism of action and Selection of anticoagulant- Wintrobe's mixture, EDTA, Heparin, Citrate, ACD. Erythropoiesis and Thrombopoiesis. Synthesis of hemoglobin and iron metabolism. Anemia: Definition, Causes, Classification & lab findings of Iron Deficiency Anemia, Megaloblastic Anemia, Hemolytic Anemia. Hemoglobinopathies: Hemophilia, Thalassemia, Sickle cell anemia. Leukemia: Classification, Blood Picture, Differentiation of Blast Cells. Hematological tests- CBC, Fetal hemoglobin test, Osmotic fragility test, Serum iron, TIBC. Blood groups-RH and ABO system. Blood transfusion: Prerequisites of transfusion.

Unit-V: Body Fluid Examination (04 hrs)

Urine examination: Physical, Chemical, Microscopic and Culture. Routine examination of faeces. Examination of body fluids, Cell counts, Semen analysis, CSF (Cerebrospinal Fluid), Chemical Tests of Gastric Content, Collection and Transportation of specimens: General Principles, Containers, Rejection, Samples- Urine, Faeces, Sputum, Pus, Body fluids, Swab, Blood.

Unit-VI: Diagnostic Cytology and Molecular Biology (08 hrs)

Normal chromosomal structure, Pre and Post-natal Cytogenetics, Cancer and Tumor markers-FISH. Aspiration Cytology: Principles, Indications, Fine Needle Aspiration Cytology (FNAC) and Fluid cytology. Exfoliative cytology: Introduction, Preparation of vaginal & cervical smears, Papanicolaou technique for the staining of cervical smears (PAP smear). Histopathology: HE staining and IHC. Role of molecular biology in diagnostics, Common techniques used in molecular biology for the detection of infectious and non-infectious disease-PCR and its variants.Stem cell banking: Applications, Procedure & Requirements of cord blood cells.

Practical:

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Preparation of reagents routinely used in Medical Laboratories.
2. Standardization of 1.0 ml of volumetric pipette.
3. Working of various instruments used in Medical laboratory: Water baths, Incubators & Hot Air Oven, Centrifuges, Balances, Autoclave, pH Meter, Vortex mixer and magnetic stirrer. Maintenance of working manuals provided with the Instruments, formulating SOPs and LOG Books for each of the Instruments.
4. Calibration and standardization of spectrophotometer and other Instruments.

5. Selection of a filter for determining the intensity of a coloured solution.
6. Determination of an unknown concentration of a coloured solution by photometric method.
7. Organize a poster making competition for standard biomedical waste disposal procedure.
8. Medico legal experts maybe invited to deliver lecture on specific topics and share their experiences.
9. Visit to hospital for demonstration of Biomedical Waste Management.
10. Visit to hospital for demonstration of advanced instrumentation and auto-analyzers.

Essential Reading:

- Sood Ramnik. (2006). Textbook of Medical Laboratory Technology.*1st edition.*Jaypee Brothers Medical Publishers. ISBN: 978-8180615917.
- Dacie and Lewis. (2017).Practical Hematology. *12th edition.* Elsevier IE. ISBN: 978-0702069307.

Suggested Reading:

- Devlin, T.M. (2011).Textbook of Biochemistry with Clinical Correlations. *7th edition*. John Wiley & Sons, Inc. (New York). ISBN: 978-0-470-28173-4.
- R. S Khandpur. (2014).Handbook of Biomedical Instrumentation. *3rd edition.* McGraw-Hill Education ISBN 978-9339205430.
- Mary C. Haven, Gregory A. Tetrault, Jerald R. Schenke. (2010).Laboratory Instrumentation. *4th edition.*Wiley India Pvt Ltd. ISBN 978-8126528578.

DISCIPLINE SPECIFIC ELECTIVE COURSE –(BIOMED-DSE-08) INTELLECTUAL PROPERTY RIGHTS FOR BIOLOGISTS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical / Practice		
Intellectual Property Rights for Biologists **BIOMED-DSE-08**	**4**	**3**	**-**	**1**	**XII Pass with Physics, Chemistry & biology**	**Basic knowledge of biology**

Learning objectives:

Upon successful completion, the certificate level course on Intellectual Property Rights (IPR) aims to achieve the following objectives:

- Familiarize students with national and international IP protection systems.
- Provide a foundation for further career development and specialization in the field of Intellectual Property Rights.
- Enhance students' understanding of Intellectual Property Rights and their significance in various fields.
- Prepare students for future career opportunities in diverse fields such as patent office/law firm clerks, patent agents, trademark agents, patent attorneys, business strategists, enforcement officers, and banks.

Learning outcomes:

The syllabus on Intellectual Property Rights (IPR) for biologists aims to equip students with a comprehensive understanding of the subject. The course outcomes include:

- Knowledge of various forms of Intellectual Property Rights, including patents, copyrights, trademarks, and trade secrets, legal frameworks and regulations governing these rights.
- Understanding of Biological Innovations and how Intellectual Property Rights apply specifically to biological innovations, such as genetically modified organisms, biotechnological inventions, pharmaceuticals, and plant varieties.
- Importance of IPR in Biotechnology and Biomedical Research.innovation, safeguards investments, and promotes the commercialization of research outcomes.
- Understanding of IP Protection Strategies in the field of biology, drafting patent applications, conducting patent searches, and navigating the patent filing process, would learn alternative forms of protection such as copyrights and trademarks, applicable to biological inventions.
- Patents of Trade mark, copyright & Design: The students will understand the legal issues related to the trade marks, logo design and the works related to arts.
- Ethical and Legal Considerations: Students will develop an understanding of the ethical and legal implications associated with Intellectual Property Rights in biology and explore issues of patent infringement, licensing, technology transfer, and access to genetic resources.

SYLLABUS FOR BIOMED-DSE-08

Unit 1: Indian Patent Act and National Policy (12 hrs)

- Understanding Intellectual Property Rights: Introduction to Intellectual Property Rights. Significance of IP and its Role in society and business, Indian Patent Act and International treaties on IP Rights (Birds eye view)

- Patent Laws and Policies : History of Patent Protection & Rational, Introduction to Indian Patent Act and its sections, National IPR Policy

Unit II: Patent Protection Procedure (10 hrs)

Function of a patent and Patentability criteria, Elements of a Patent and Application forms (Form 1 and Form 2). Types of Patent Applications. Signification of Provisional patent Filing. PCT system, IP infringement and IP enforcement. Plant variety protection and farmers rights Acts and authority in India

Unit III: Patent Prosecution and IP issues in the current scenario (10 hrs)

First Examination Report (FER) and Responding to FER and hearing notice. Exercises and Ecommerce. Interaction Between IP Law and Competition Law regulating anti-competitive conduct of companies. IP Rights in digital environment and open source & open Access, Plagiarism. Importance of IP policy for an organization

Unit IV: Geographical indications & Trademarks (08 hrs)

Brief introduction to Legal framework for GIs in India and Impact of GI registration in India. Importance of Trademarks , Salient features of Trademark law of India and Trademark filing and prosecution in India. Madrid System

Unit V: Registration of Copyright, Designs and Lay out of Integrated circuits (05hrs)

Salient elements of Indian Copyright Act, Law relating to Layout designs of Integrated Circuits and Design Act. Registration of Copyrights, Designs, The Industrial Property System

Practical (30 hrs)

1. Drafting of specifications, claims and Patent Filing:

a) Drafting a patent specification

b) Claims Drafting

c) Patent filing – examples (05)

d) Exercises (05)

2. Industrial Designs and Layout design of Integrated circuits in India.
3. **Case studies** : (a) Patents as assets; (b) Drug pricing as a result of patent filing. (c) Recent cases related to the provisions of Section 3(d) of The Patents Act (Novartis vs Generic Manufacturers, Roche vs Cipla, Astra Zeneca Vs Natco Pharma). (d) Traditional knowledge and IP system;

   (e) Patenting of genetically-engineered micro-organism (Diamond Vs Chakravarthy); (f) Infringement cases; (g) Biopiracy cases *(Hoodia case, the Quinoa case, the Enola bean case, The neem patents);* (h) Trade secrets;

Essential Reading

- Intellectual property: A power tool for Economic Growth: Kamal Idris, Published by World Intellectual Property Organization, 2003. ISBN: 9280511149, 9789280511147
- Intellectual property and Human Development : Current trends and future Scenarios: T. Wong and G. Dutfield, Publisher Cambridge University Press, 2010. ISBN-13 : 978-0521190930
- Intellectual Property laws, Publisher: Universal Law Pub Co. P. Ltd., Delhi, 2015. ISBN-13 : 978-9350355855
- Intellectual property Law in India, Third Edition. Tamali Sen Gupta, Dhruv Shekhar, Publisher: Kluwer Law International, 2022. ISBN-13 : 9789403548111
- IIMA Business and Intellectual Property: Protect Your Ideas: Anurag K. Agarwal, Random House Publishers India Pvt. Limited, 2016. ISBN-13, 978-8184001402
- Technology Licensing and Development Agreements By Cynthia Cannady, Oxford University Press, 2013. ISBN-13: 978-0195385137
- Deborah Bouchoux : The Law of Trademarks, Copyright, Patents and Design, 2012. ISBN-13 , 978-1111648572.

Suggested Reading

- Office of the Controller General of Patents, Designs & Trade (CGPDTM): Manual of Geographical Indications Practice and Procedure; Manual of Patent Office Practice and Procedure; Manual of Designs Practice and Procedure; Revised Draft Manual of Trademarks Practice and Procedure.
- WIPO: WIPO Guide To Using Patent Information; WIPO Intellectual Property (IP) Audit, : WIPO Patent Drafting Manual, WIPO: The Value of Intellectual Property, Intangible Assets and Goodwill.
- Journal of Intellectual Property Rights 2007 and 2009.
- OECD Report on Patents and Economic Performance, IP guidelines from Patent office.
- Patentability of Software in India - (Lex Orbis).
- Acts : Indian Patent Act (amended), Indian Trademark Act (amended), Indian Copyright Act (amended), Indian Design Act (amended), Indian Plant variety and Farmers Right Act (Amended), Indian Biodiversity Act ,Indian GI Act

DISCIPLINE SPECIFIC ELECTIVE COURSE (BIOMED-DSE-09) DRUG DESIGN AND DISCOVERY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Drug Design and Discovery **BIOMED-DSE-09**	**4**	**3**	**-**	**1**	**XII Pass with Physics, Chemistry & biology**	**Basic Knowledge of Medicinal Chemistry**

Learning objectives

The Learning Objectives of this course are as follows:

1. The students will learn the fundamental computational techniques used in drug design and discovery that can be applied to study problems in biology.
2. The students will develop scientific and hands-on practical skills and abilities to plan and carry out drug design projects to design a druggable ligand using computer-aided drug design tools.
3. The students will develop skills that will be useful for higher studies in biomedical research.

Learning outcomes

Having successfully completed this course, students shall be able:

1. To use structural databases and computer programs to visualize three-dimensional structures of the proteins and to analyse the relationship between structure and function.
2. To describe molecular mechanics force fields, parameterization, and their limitations and procedure for energy minimization of simple systems.
3. To understand the principle and carry out basic steps involved in molecular dynamics simulations.
4. To interpret molecular dynamics results vis-a-vis their biological significance and limitations.
5. To understand the drug discovery process from molecules to new medicines, challenges encountered in the development, manufacturing, and regulatory approval.

SYLLABUS OF BIOMED -DSE- 9:

Unit I: Structure of Proteins (08 hrs)

Basics of biomolecular structure- primary, secondary tertiary and quaternary protein structures, Ramachandran plot, various parameters of protein secondary structure, introduction to peptide planarity, chirality, side-chain packing.

Molecular structure databases and visualization, The PDB and mmCIF formats, structure classification databases (SCOP and CATH), structure comparison and alignment, structure and functional assignment; secondary structure assignment, identifying structural domains in proteins.

Unit II: Proteins as Drug Targets (08 hrs)

Chemical attributes of drug targets, candidate gene prioritization, experimental validation, practical aspects and case studies, structural bioinformatics in drug discovery, protein structure prediction (homology modelling, fold recognition and, *ab initio* methods).

Unit III: Ligand and Pharmacophore-based screening methods for Lead Discovery (07 hrs)

Traditional and rational drug discovery methods, SAR, drug discovery pipeline, , hit and lead discovery, chemical databases and 2D substructure searching, , molecular descriptors and fingerprints, molecular similarity (or diversity) and similarity searching, selecting 'diverse sets of compounds', ligands and targets, chemical libraries, Lipinski's rule of five, QSAR, deriving and using 3D pharmacophores, 3D database searching, strengths and limitations of pharmacophore-based virtual screening

Unit IV: Structure based drug design methods (07 hrs)

Introduction to structure-based drug design methods, , , library design, binding site prediction, virtual screening, , docking and scoring methods, rigid and flexible docking, induced fit methods, *de novo* drug design, calculation of binding free energies molecular affinities and assemblies, design against protein-protein interactions.

Unit V: Introduction to Molecular Mechanics (08 hrs)

Scope of computational chemistry, Potential energy surfaces and optimization methods, , Introduction of *ab initio* methods. Electrostatics for force fields, basics of molecular dynamics simulation, introduction to Monte Carlo methods, electrostatics and solvation in biomolecules; calculation of free energy, Poisson-Boltzmann surface area.

Unit VI: Overview of the Clinical Evaluation and Development Process (07 hrs)

Introduction to drug development pathway: how to go from molecule to medicine, pharmacological and toxicological evaluation (prediction as well as *in vitro/ in vivo* methods), preclinical evaluation methods, an overview of the clinical process, clinical safety and pharmacovigilance.

Practical (30 hrs)

1. To predict secondary e.g PSIPred, and tertiary structures of proteins e.g. Swiss Model.
2. To calculate the total energy of a biomolecule e.g Charmm-GUI, AMBER, Chimera.
3. To build a ligand- *ab initio* from similar ligands with and without a known macromolecular target. SWISS-DOCK
4. To perform virtual screening and molecular docking using Autodock, Chimera.
5. To calculate energy minimization (EM) through different EM methods. Charmm-GUI, Chimera
6. To calculate binding free energy/MMPBSA through tools/ servers. AMBER
7. To perform MD simulations e.g. Charmm GUI, NAMD

8. To design a druggable ligand using computer-aided drug design tools.

Essential readings:

- Stromgaard, K., Krogsgaard-Larsen, P., & Madsen, U. (Eds.). (2016). Textbook of drug design and discovery, Fifth Edition. United States: Taylor & Francis. ISBN: 9781315354545.
- Gu, J., & Bourne, P. E. (Eds.). (2011). Structural bioinformatics, Second Edition. John Wiley & Sons. ISBN: 9781118210567.

Suggested readings:

- Rostron, C. (2020). Drug Design and Development. United Kingdom: Oxford University Press. ISBN: 9780198749318.
- Jhoti, H., & Leach, A. R. (Eds.). (2007). Structure-based drug discovery. Springer Netherlands. ISBN: 9781402044076.
- Gasteiger, J., & Engel, T. (Eds.). (2006). Chemoinformatics: a textbook. John Wiley & Sons. ISBN: 9783527306817.
- Bajorath, J., (2013) Chemoinformatics for Drug Discovery, John Wiley & Sons, ISBN: 978-1-118-13910-3.
- Leach, A. R. (2001). Molecular modelling: principles and applications. Pearson Education. ISBN: 9780582382107.

Pool of Generic Electives (Semester III Onwards)

GENERIC ELECTIVES (BIOMED-GE-04): PANDEMIC: CHALLENGES AND PREPAREDNESS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Pandemic: Challenges and Preparedness **BIOMED-GE-04**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of Biology-**

Learning Objectives

The Learning Objectives of this course are as follows:

- Current scenario of covid outbreak all over the world made everyone curious about pandemic, its challenges and how to prepare for dealing with it.
- In this context we designed this paper to make students aware about pandemics caused by various pathogens.
- Course describes different pandemic outbreaks and strategies adapted to combat the transmission of pathogen and their neutralization.
- The course also explains the different therapeutic approaches for the elimination and cure of patients suffering from pandemic infections.

Learning outcomes

The Learning Outcomes of this course are as follows:

- This unit helps students to understand the difference between endemic, epidemic and pandemic.
- It makes students familiar with various pandemics that have spread in last century and are caused by different types of pathogens such as virus, bacteria and fungi.
- Students will learn extent of spread of pandemic worldwide, its timeline, death rate and other statistical data.
- This unit will explain about the infectious diseases and process of invasion by microbes.

- It will also helpful to understand preventive measures of infection transmission and about mutant strains which are associated with recurrent outbreaks.
- Students will learn about different treatment strategies for the patients suffering from any infection, along with specific precautions for handling patients with co-morbidities/ elderly persons. The content of this unit will be helpful to explain about plasma therapy and booster doses. Some basic concept of psychological counselling will help to reduce the depression and anxiety faced by individuals during pandemic outbreak.
- This unit describes different methods and equipments used during an out breaks to minimize the contamination and cross transmission of infection and its spread.
- This will help students to learn the usage of PPE kits, mask, sanitization, quarantine and significance of social distancing.
- Current unit, emphasizes about the history of vaccine, process of active and passive immunization, different types of vaccines and their effectiveness to control any pandemic, vaccines developed in India against covid-19.
- Students will learn hands-on training for important techniques used in the detection and diagnosis of various types of pathogens and associated protocols.
- Last unit of the course will focus on awareness and sensitization programs (eg. SOPs), health and hygiene and many issues related to public health. Also possible global approach to strengthening the health infrastructure and disease surveillance shall be elaborated.

SYLLABUS OF BIOMED-GE-04

Unit I: Introduction to Pandemics: (07 Hrs)

General concepts of endemic, epidemic and pandemic; Historical background of pandemics: Rabies, plague, small pox, cholera, Spanish Influenza, AIDS, Avian bird flu, Swine flu, MERS, SARS and covid-19 pandemic. Timeline of Covid- 19. Extent of spread, worldwide statistics and death rate. Statistics of affected nations worldwide and in India; symptoms, extent of spread and containment

Unit II: Infectious Disease: (05 Hrs)

Structure of causative agent, invasion into human body, etiology and strategies currently used to block infection process, common mutant strains responsible further outbreaks of the pandemics

Unit III: Emerging Therapies, Natural Protection and strengthening immune system: (06 Hrs)

Drugs used to cure Avian bird flu, Swine flu and covid-19. First line of treatment at home additional care of person with co-morbidities / elderly person. Convalescent plasma therapy, Placebo effect, alternative therapies and immunity boosters used during pandemic and psychological counseling and countering depression.

Unit IV: Precautions and Prevention: (06 Hrs)

Quarantine protocol at home, for frequent fliers, hospital exposure, and workplace exposure. Precautionary measures such as PPE clothing, gloves, masks, social distancing, frequent washing of hands with soap, use of sanitizers, disinfection strategies.

Unit V: Vaccines: An effective tool for prevention of pandemics: (09 Hrs)

Historical perspective of vaccination, active and passive immunization; Vaccination drive, types of vaccines: Live attenuated vaccines, inactivated vaccines, subunit vaccines, multivalent vaccine, recombinant vector vaccines and DNA vaccines. Types of vaccines developed against Covid-19 worldwide, Their effectiveness and side effects. Vaccines developed in India for adults (Covaxin and Covishield) and vaccines for children. Limitations in effective development of covid-19 vaccine.

Unit VI: Techniques for diagnosis and detection of disease: (06 Hrs)

Antigen-antibody based detection techniques: Lateral flow technique, RAPID and RT-PCR test with complete protocol. Probes for virus detection.

Unit VII: Challenges and Preparedness: **(06 Hrs)**

Awareness and sensitization programs (SOPs) about general health and hygiene. Funding in research on issues related to public health and protection of environment. Global health approach with multidisciplinary collaborations. Pandemic preparedness and disease surveillance with strong health infrastructure.

Practical component (30 Hrs)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. A case study of any one pandemic of past.
2. A case study of any one emerging pandemic.

3. Detection and diagnosis using antigen and antibody in the sample.
4. Demonstration of the PCR machine
5. Video demonstration of Covid-19 lateral flow technique
6. Demographic analysis of extent of spread both national and international.
7. Project work

Essential readings:

- Park, K. (2021), 26th Edition, *Park's Textbook of Preventive and Social Medicine*, Banarsidas Bhanot Publisher, ISBN-13 : . 978-9382219163
- Madigan M. T, Bender K.S, Buckley D.H, Sattley W.M, Stahl D.A (2021) 16th edition, Brock Biology of Microorganisms, Pearson Publisher, ISBN-139780135861717.
- Punt, J. Stranford, S. Jones, P. and Owen, J. (2019). 8 th Edition. Kuby Immunology. New York, USA: W.H. Freeman and Company. ISBN- 13: 978-1464189784.
- Willey, J., Sherwood, L., and Woolverton, C.J. (2016). 10th Edition. Prescott's microbiology. New York, USA: McGraw-Hill Education. ISBN-13: 978-1259281594.

Suggestive readings:

- Bonita, Ruth, Beaglehole, Robert, Kjellström, Tord & World Health Organization. (2 (2006nd edition. *Basic Epidemiology*, World Health Organization, ISBN 978 92 4 154707 9.

GENERIC ELECTIVE-05 (BIOMED-GE-05) UNDERSTANDING GENETIC BASIS OF DISEASES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Understanding Genetic Basis of Diseases BIOMED-GE-05	4	3	-	1	XII Passed	Basic knowledge of Biology

Learning Objectives

- The course is designed to provide insight about the importance of our genetic material.
- Students will be taught different types of changes that can take place in our genetic material and their repercussions.
- Students will be briefed as to how even minor changes in such a complex genetic system can lead to serious defects and disorders.

Learning outcomes

Having successfully completed this course, students will understand:

- The basic structural arrangement of our genetic material, its location within the cells and how it contributes to the unique features of each individual organism.
- Possible changes that can occur in the chromosomes at the macro level and what serious consequences this might have to the bearing individuals will be taught to the students.
- Not only the structural features but also the correct dose of the chromosomes present in our cells plays an important role in regulating normal body functioning. The same will be taught by citing examples of disorders associated with both extra as well as deficient chromosome numbers.
- The basic Mendelian pattern of inheritance. Students will also learn about different changes that can occur within a single gene, the diseases associated with them and how these changes can be inherited from one generation to the next.

SYLLABUS OF BIOMED-GE-05:

Unit I: Organization of human genome (09 Hrs)

Basic structure of DNA and chromosomes, euchromatin, heterochromatin. A brief overview of the human nuclear and mitochondrial genome, Concept of allele, haploid and diploid. Genetic Variations-Polymorphism vs mutations. Types of mutations: Somatic vs germline.

Unit II: Structural chromosomal abnormalities (06 Hrs)

Different types of structural chromosomal abnormalities (deletions, duplications, inversions and translocations) and their associated disorders (Cri-du-chat, Wolf-Hirschhorn, Charcot-Marie-Tooth disease Type 1, Pallister Killian, Hunter syndrome, Walker-Warburg, CML).

Unit III: Numerical Chromosomal abnormalities (06 Hrs)

Concept of non-disjunction anaphase lagging, genomic imprinting, uniparental disomy, euploidy, aneuploidy and associated disorders (Down Syndrome, Edward Syndrome, Patau Syndrome, Turner Syndrome, Klinefelter Syndrome, Prader-Willi Syndrome, Angelman Syndrome).

Unit IV: Monogenic Disorders (12 Hrs)

Mendelian inheritance (autosomal and sex-linked). Types of gene mutations (substitution, indels, dynamic) and associated disorders: (Achondroplasia, Huntington’s disease, sickle cell anaemia, cystic fibrosis, thalassemia, Rett Syndrome, haemophilia, colour blindness, phenylketonuria, albinism, maple syrup urine disease, alkaptonuria).

Unit V: Other genetic disorders (07 Hrs)

Multifactorial disorders like Cancer, Alzheimer’s disease, Arthritis, Diabetes

Unit VI: Genetic counselling (05 Hours)

Invasive and non-invasive methods of prenatal diagnosis and screening (Down syndrome, Thalassemia). Genetic counselling for risk assessment and possible treatment and management strategies.

Practical component (30 hrs)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. PCR for polymorphism detection
2. Study of chromosomal abnormalities through karyotypes
3. Pedigree charts for disorders likeHuntington's disease, colour blindness, sickle cell anaemia
4. Pedigree analysis for determining inheritance and risk assessment
5. Case studies for disorders like cancer, diabetes
6. Case studies for genetic counselling
7. Determination of linkage and cross-over analysis (through two point test cross and three point test cross data).
8. Analysis of Tetrads from *Saccharomyces cerevisiae.*

Essential readings:

- Klug, W. S., Cummings, M., Spencer, C. A., Palladino, M. A., Darrell K. (2019). 12th Edition. Concepts of genetics. San Francisco, NY:Pearson ISBN-13: 9780134604718.
- Snustad, D.P. and Simmons, M.J. (2019). 7th Asia Edition. Principles of genetics. New York, USA: John Wiley and Sons. ISBN-13: 9781119657552.
- Strachan, T. and Read, A. (2018). 5th Edition. *Human molecular genetics*. Florida, USA: CRC Press, Garland Science. ISBN: 978-0815345893.
- Gardner E. J., Simmons M. J. and Snustad D. P. (2006). 8th edition Principles of genetics. USA. Wiley. ISBN-13: 978-8126510436.

Suggestive readings:

- Speicher, M.R., Antonarakis, S.E. and Motulsky, A.G. (2010). 4th Edition. *Vogel and Motulsky's Human genetics: Problems and approaches*. Berlin, Germany: Springer Verlag. ISBN: 978-3540376538.
- Wilson, G.N. (2000). 1st Edition. *Clinical genetics: A short course*. New York, USA: Wiley-Liss, ISBN: 978-0471298069.

GENERAL ELECTIVE -06 (BIOMED-GE -06): STATISTICAL CONCEPTS IN BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Statistical Concepts in Biology BIOMED-GE-06	4	3	-	1	XII Passed	Basic knowledge of Biology

Learning Objectives

- The purpose of the course is to teach fundamental concepts and techniques of descriptive and inferential statistics with applications in health care, medicine, public health, and epidemiology.
- The course will prepare students to collect, analyze and interpret biological data sets and provide quantitative evidence to support scientific conclusions

Learning outcomes

Having successfully completed this course, students shall be able to:

- Recognise the importance of statistics in biological sciences, understand the different types of data and difference between population and sample.
- Learn how to group data into tabular form and present it in various graphical forms.
- Learn the calculation and application of measures of central tendency and measures of dispersion in data representation.
- Understand concepts of discrete and conditional probability and apply these concepts to biological applications.
- Understand the significance and basic concepts of correlation and simple linear regression analysis.
- The student will be able to learn the process of hypothesis formulation, and utilization of appropriate test of significance for biological data analysis.

SYLLABUS OF BIOMED-GE-06

Unit I: Types of Statistical Data and Measurement **(06 Hrs)**

Importance of Statistical Studies in Biology. Types of Data in Biology: Qualitative, Quantitative and Random (Discrete and Continuous) Variables. Scales of Measurement: Nominal, Ordinal, Interval and Ratio scale. Sample and Population.

Unit II: Data Organization and Graphical Representation **(06 Hrs)**

Ordered array, Grouped Frequency Distribution Table. Charts and Diagrams: Bar diagram, Pie chart, Histogram, Frequency Polygon, Line chart, Cumulative Frequency Curve and Scatter diagram.

Unit III: Descriptive Statistics **(10 Hrs)**

Measures of Central Tendency: Mean, Mode, Median, Partition Values. Measures of Dispersion: Range, Standard Deviation, Coefficient of Variance, Covariance. Concept and Importance of Skewness and Kurtosis.

Unit IV: Probability **(07 Hrs)**

Concepts of Probability, Addition and Multiplication Rules and Conditional Probability. Use of Probability in Assessing Validity (Sensitivity/Specificity) of a Diagnostic Test.

Unit V: Correlation and Linear Regression Analysis **(07 Hrs)**

Correlation Analysis: Scatter diagram, Pearson's and Spearman's Coefficients of Correlation, Coefficient of Determination. Regression Analysis: Concept of Line of Best Fit, Equations of Lines of Regression and their Applications in Biostatistics.

Unit V: Inferential Statistics **(09 Hours)**

Sampling Distribution and Standard Error. Concept of Null and Alternate Hypothesis. Biological Data Analysis using Z-Test (Single Mean and Difference of Means), Student's T-Test (Single Mean, Difference of Means and Paired T-Test) and F-Test.

Practical **(30 hrs)**

The experiments are designed for students to learn the usage of statistical methods for biological data analysis using spreadsheets.

1. Hands-on training of Microsoft excel software to perform basic operations, commands and functions.
2. Organize the given data set and make frequency distribution table.
3. Present data in various charts or diagrams (bar diagrams, histograms, pie charts, Line graph and scatter diagrams).
4. Computing measures of central tendency and dispersion using biological data.
5. Correlation analysis to determine the strength of relationship between a set of dependent and independent variable.
6. Compute regression equations to predict the value of dependent variable.
7. Perform Z-test (Single Mean and Difference of Means).
8. Perform student's t-test (Single Mean, Difference of Means and Paired T-Test)

Essential readings:

- Daniel, W.W. and Cross, C.L. (2019). 11th Edition. Biostatistics: A foundation for analysis in the health sciences. New York, USA: John Wiley & Sons. ISBN-13: 9781119588825.
- Triola M.M., Triola M.F., Roy J. (2019). 2nd Edition. Biostatistics for Biological and Health Sciences. Harlow, UK: Pearson Education Ltd. ISBN-13: 9789353436537.
- Pagano, M. and Gauvrean, K. (2018). 2nd Edition. Principles of Biostatistics. California, USA: Duxbury Press. ISBN-13: 9781138593145.
- Schmuller, J. (2016). 5th Edition. Statistical Analysis with Excel for Dummies. New York, USA: John Wiley & Sons. ISBN-13: 9781119844549.

Suggestive readings:

- Zar, J.H. (2014). 5th Edition. Biostatistical analysis. USA: Pearson. ISBN-13: 9789332536678.
- Glantz, S. (2012). 7th Edition. Primer of biostatistics. New York, USA: McGraw-Hill Medical. ISBN-13: 9780071781503

GENERIC ELECTIVE COURSE -07 (BIOMED-GE-07): BIOCHEMICAL BASIS OF LIFE

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Biochemical Basis of Life BIOMED-GE-07	4	3	-	1	XII Passed	Basic knowledge of Biology

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this course is to address how the wonderful and remarkable properties of living organisms arise from the various biomolecules, the building blocks.
- The course focuses on the chemical complexity and organization of molecules in a living cell, extraction and transformation of energy
- It gives insights into the changes that occurred during the gradual evolution of life.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The fundamental Chemistry of Life: Students will gain an understanding of the elements found in living systems and appreciate the importance of water as the solvent for living systems. It is important to learn about the units used for expressing the biochemical basis of a living system. Students will learn the unit system for the molecular mass of biomolecules, units used for the concentration of solutions, and units for expressing the distances, etc.
- Cellular foundations of life**:** A stepwise organization of a living system, starting from the smallest unit to an entire living organism would be the focal point in this unit.
- Molecular basis of life**:** Students will understand the monomeric forms of different types of biomolecules. In addition, the relationship between the structure and function of biomolecules would also be learnt.

- Physical foundation of life: Students would learn the concept of enthalpy, entropy and free energy in a living system and understand the importance of the energy currency and the significance of coupled biochemical reactions.
- Biochemical events in the origin of life: Students would learn the origin of life and the nature of transformative changes that occurred for life to evolve from the pre-biotic world to the modern times.

SYLLABUS OF BIOMED-GE-07

Unit I: The fundamentals of chemistry of life **(06 Hrs)**

Carbon chemistry of life, structure and importance of water, diverse inorganic ions, major elements (C, H, O, N, S), trace elements. Units used in biochemistry such as those expressed for the atomic mass unit (Daltons), concentration (moles/litre) and distance (in nanometer-scale).

Unit II: Cellular foundations of life **(06 Hrs)**

Levels of organization in a living system. The important features of living cells, subcellular organelles in Eukaryotic cells and subcellular organization in Prokaryotic cells. Brief description on Phototrophs, Chemotrophs, Autotrophs and Heterotrophs.

Unit III: Molecular basis of life **(12 Hrs)**

Common functional groups and linkages in biomolecules.

Macromolecules: classification, building blocks, structural and functional diversity.

Structural and functional forms of macromolecules: Proteins (collagen, albumin, hormones (insulin), enzyme (proteases, nucleases, amylases and lipases); Polysaccharides (starch, glycogen, cellulose), Nucleic acids, Lipids (cholesterol and triglycerides).

Unit IV: Physical foundation of life **(11 Hrs)**

Enthalpy, Entropy, Free Energy, Standard Free Energy, Equilibrium constant, Open and Closed systems, Endergonic and Exergonic reactions, the energy currency in a biological system (ATP), Energy coupling reactions.

Unit V: Biochemical events in the origin of life **(10 Hrs)**

Landmark events in the evolution of life. Biochemical basis of the origin of aerobic and anaerobic world. Evolution of biological monomers and polymers from pre-biotic compounds. Properties of DNA as genetic material. Structural and functional analysis of eukaryotes and prokaryotes, with suitable examples.

Practical components **(30 Hours)**

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Preparation of buffer at a specific molarity and pH.
2. Numerical problems based on Enthalpy, Free Energy and Entropy.
3. Comparative analysis of protein content in egg white and egg yolk, using Biuret's method.
4. Detection of a glucose polymer (starch) in rice/potato/corn, using iodine test.
5. To assess the differential solubility of lipids in aqueous and organic solvents.
6. Extraction of DNA from plant/microbial cells by the spooling method.
7. Demonstration of agarose gel electrophoresis for analyzing the isolated DNA.
8. To compare the structural features of a prokaryotic and eukaryotic cell by studying their electron micrographs.

Essential readings

- Nelson, D.L. and Cox, M.M. (2021). *Lehninger: Principles of Biochemistry* (7^{th} ed.). W.H. Freeman & Company (New York), ISBN:13:9781319322328
- Pratt, C.W. and Cornely, K.(2017). *Essential Biochemistry* (4^{th} ed.) John Wiley& Sons, Inc.ISBN:9781119012375
- Plummer, D.T. (2012). *An Introduction to Practical Biochemistry*. New Delhi, India: McGraw-Hill College.

Suggestive readings

- Berg, J., Gatto, G., Stryer, L. and Tymoczko, J. L. (2019). *Biochemistry*. New York, USA: W. H. Freeman and Company.
- Campbell, M. K. and Farrell, S. O. (2017) 9th Edition. *Biochemistry*. Boston, USA: Brooks/Cole Cengage Learning. ISBN-13: 978-1305961135

GENERAL ELECTIVE -08 (BIOMED-GE-08): DISEASES IN EVERYDAY LIFE

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Diseases in Everyday Life BIOMED-GE-08	4	3	-	1	XII Passed	Basic knowledge of Biology

Learning Objectives

The Learning Objectives of this course are as follows:

- Diseases are not new to human beings but if we are familiar with them, it is easy to manage.
- The course has been designed to familiarize students with most common diseases in everyday life. Students will be able to differentiate between infectious and non-infectious diseases.
- Students will learn about the causative organism of these diseases and their symptoms. A brief description related to treatment and management methods will also be included in the syllabus.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Initially students will understand about diseases and various approaches to classify different types of diseases.
- A detailed description of various diseases caused by infectious agents has been included in the syllabus. As all the diseases are not infectious, students will learn differentiate between communicable and non-communicable diseases with examples of most common disorders.
- A brief overview about degenerative disorders such as Parkinson’s, Alzheimer’s, Osteoarthritis, Osteoporosis have also been included in the syllabus to enrich the learning of students.
- Majority of human population is malnourished and suffer from many deficiency disorders, thus students are familiarized with common deficiency diseases such as Anaemia, Goitre, Kwashiorkor, Beri-Beri, Scurvy and Rickets have also been included.

- Many cell types in blood and immune components sometime leads to anomalies which may be associated with any disorder. Keeping this in mind, some common immune disorders are briefly added to the syllabus.

SYLLABUS OF BIOMED-GE-08

Unit I: Introduction: (12 Hrs)

Disease classification: Overview of disease condition related to human body: Communicable and non-communicable diseases. Five "F' of communicable diseases [Food (contaminated), Fingers (unclean), Faeces, Fomites, and Flies] Genetic Diseases, Toxic effect of drugs and Chemicals (toxic gases and radiation),Auto immune disorders, nutritional deficiency (Effect of nutrition) (deficiency of Vitamin B12, Vitamin C), Route of transmission, Infectious dose, Communication by vector, Allergic diseases

Unit II: Communicable (Infectious) diseases: (09 Hrs)

a. Diseases transmitted directly: air borne (Mycobacterium) and water borne (Cholera) food borne (typhoid).Epidemiology, cause, clinical feature and prevention. STDs (with examples).Diseases caused by Virus, bacteria, fungus and protozoa/ helminths.
b. Vector borne diseases: mosquito, (Malaria, dengue and Chikungunya), cockroaches and flies, how they spread diseases and methods of prevention, diagnosis (basic).

Unit III: Non-communicable diseases: (06 Hrs)

a. Diabetes, hypertension and cancer (Brief discussion and special emphasis on prevention).
b. Down syndrome and colour blindness.

Unit IV: Degenerative Diseases: (07 Hrs)

Parkinson's/Alzheimer's, Osteoarthritis, Osteoporosis.(Special focuses on factors related to Lifestyle).

Unit V: Deficiency Diseases: (05 Hrs)

Anaemia, Goitre, Kwashiorkor, Beri- Beri, Scurvy and Rickets (Main emphasis on nutritional factors)

Unit VI: Blood disorders and Autoimmune Disease: (06 Hrs)

a. Sickle cell anaemia,haemophilia, thalassemia, blood incompatibility disorder, Rh factor.
b. Graves' disease, Rheumatoid Arthritis and Psoriasis.

Practical component **(30 Hrs)**

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. A case study of any communicable disease outbreak.
2. A case study on the prevalence of degenerative diseases (Parkinson's diseases/ Alzheimer's) in our country
3. Study different parameters responsible for malnutrition in human population and appropriate management strategies
4. Brief case study non communicable disease associated with lifestyle (hypertension and colourblindness)
5. How much we are aware about immune disorders? Give a small intra college survey to support the statement.
6. Preparation of a brief flow chart depicting classification of diseases.
7. Case study about minamata disease / Hiroshima and Nagasaki / Bhopal gas tragedy.
8. Effect of pesticides on human beings (taking example of anyone state in India).
9. Identification of common diseases caused by vectors.

Essential readings:

- Park, K. (2021), 26th Edition, *Park's Textbook of Preventive and Social Medicine*, Banarsidas Bhanot Publisher, ISBN-13 : . 978-9382219163
- Punt, J. Stranford, S. Jones, P. and Owen, J. (2019). 8 th Edition. Kuby Immunology. New York, USA: W.H. Freeman and Company. ISBN- 13: 978-1464189784.
- Cappuccino, J.G. and Sherman, N. (2013). 10th Edition. Microbiology: A laboratory manual. California, USA: Benjamin Cumming. ISBN-13: 978-0321840226.
- Willey, J., Sherwood, L., and Woolverton, C.J. (2016). 10th Edition. Prescott's microbiology. New York, USA: McGraw-Hill Education. ISBN-13: 978-1259281594

Suggestive readings:

- Tille, P. (2013). 13th Edition. Bailey & Scott's diagnostic microbiology. Missouri, USA: Mosby Publishers. ISBN-13: 978-0323083300.

- Madigan, M.T., Martinko, J.M., Stahl, D.A. and Clark, D.P. (2010). 13th Edition. Brock biology of microorganisms. California, USA: Benjamin Cumming. ISBN-13: 978- 0321649638.

- Tortora, G.J., Funke, B.R. and Case C.L. (2006). 9th Edition. Microbiology: An introduction. California, USA: Benjamin Cummings. ISBN-13: 978-0536292117.
- Bonita, Ruth, Beaglehole, Robert, Kjellström, Tord & World Health Organization. (2 (2006nd edition. *Basic Epidemiology*, World Health Organization, ISBN 978 92 4 154707 9.
- Pelczar, M.J (2001). 5th Edition. Microbiology. New York, USA: McGraw Hill International. ISBN-13: 9780074623206.

GENERAL ELECTIVE -09 (BIOMED-GE-09): HEALTH AND BODY DEFENSE SYSTEM

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Health and Body Defense System **BIOMED-GE-09**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of Biology**

Learning Objectives

The Learning Objectives of this course are as follows:

- Characteristics of a healthy body and ways to improve one's health and well-being.
- Body defense system is a comprehensive study of the organization and functioning of the immune system with its network of cells and molecules. Understanding the biology of the immune system is key to developing strategies towards prevention and cure to a number of disorders and diseases that result due to malfunctioning and dysregulation of the immune system.
- This paper covers the organization and functioning of the various branches of immune system, namely, Innate and adaptive Immunity to combat different pathogens. Various Immunological techniques will also be taught to the students.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Students learn various aspects of health and immune system in normal and infectious stage which equips students to design better strategies for combating the immunological disorders. Students will be given an overview to various pathogens and immune system in Invertebrates and Vertebrates.
- Students learn historical perspective of the extensive field of Immunology. They are introduced to the important concepts of Immunology.

- Students will be familiarized with origin and maturation of all blood cell types in bone marrow and thymus. They will understand the process of haematopoiesis, functions of various types of cells and roles played by them in generating immune responses against pathogens.
- The unit entails different barriers of Innate Immunity, Cells, Complement system, Patterns on the pathogens recognized by receptors of Innate Immune system, pathogen killing by the immune cells and concept & the importance of the Inflammation in an Immune response.
- Students will learn about the cells of adaptive immune system, the concept of antigen, antibody molecules and role of major histocompatibility complex & associated cells in the processing and presentation of antigen. The students will explore the branches of adaptive immunity - the humoral and cell mediated, their components and interplay of these components in combating the infection. The students will also be able to understand the significance of various kinds of growth factors and cytokines in the activations of various lymphocytes
- The students will be given knowledge about the principle, methodology and applications of various laboratory techniques involving antigen-antibody reaction.
- Vaccine based immunotherapies and their designing will assist them to think about new path for combating with pathogens and working mechanisms of immune system.
- The students will be made aware about the importance of diet and lifestyle in promoting Immunity and health.

SYLLABUS OF BIOMED-GE-09

Unit I: Hallmarks of Health (03 Hrs)

Basic aspects of healthy body: Cells, Tissue and Organ system, difference between prokaryotes and eukaryotes. Key differences between bacteria, fungi, protozoans and viruses.

Requirements for ahealthy body according to age and gender. Survival strategies of host against the invading pathogens: bacterial defense against bacteriophage, immune system of Plants, invertebrates (Mollusca) and vertebrates

Unit II: Introduction to Immune system: (03 Hrs)

Historical background, general concepts of the immune system, innate and adaptive immunity; active and passive immunity.

Unit III: Organization of Immune System: (03 Hrs)

Lymphoid Organs: thymus, bone marrow and haematopoiesis, lymph nodes, spleen.

Unit IV: Innate Immune response (08 Hrs)

- Physical and Chemical barriers
- Cells of the innate immune system: Natural Killer cells, monocytes and macrophages; neutrophils, eosinophils, basophils, mast cells and dendritic cells: Structure, Phenotypic and functional aspects.
- Complement system: Components of the complement activation classical, alternative and lectin pathways; biological consequence of complement activation.
- Mechanisms of pathogen killing by macrophages and neutrophils: Receptor/non receptor mediated endocytosis, phagosome formation, phagolysosome formation, respiratory burst phenomenon, basic pathways of oxygen dependent and oxygen independent killing mechanism.
- Inflammation: concept, hall marks of inflammation.

Unit V: Adaptive Immune Response (10 Hrs)

- Cells of the adaptive immune system: T and B lymphocytes
- Characteristics of adaptive immune response: self and non-self recognition, specificity, diversity and memory, primary and secondary immune response, allergen/ allergy.
- Antigens: antigenicity and immunogenicity, haptens. Properties (foreignness, molecular size, heterogeneity, route and dose of administration, solubility and degradability); host factors (genotypes, gender, nutrition) Blood group antigens and transfusion reactions.
- Basic function of Major Histocompatibility Complex
- Importance of Antigen presentation
- Types of antibodies and their function,
- Cell mediated immune response: Major steps in T cell differentiation in thymus: thymic selection, self MHC restriction, T cell receptor assembly. Phenotypic characteristics of naïve T-cells ($CD4^+$ and $CD8^+$ T-cells). Migration of naïve T-cells from thymus to secondary lymphoid organs. Activation of T-cells, proliferation of clonally selected T cells and their effector functions, concepts of T-helper 1 (TH_1) and T-helper 2 (TH_2) cells. Basic introduction to cytokines: IL-2, IL-4 and IFN-γ

- Contribution of MHC, B-cell receptor (BCR) and T-cell receptor (TCR) to diversity in adaptive immune response

Unit VI: Immunological Principles of Various Reactions and Techniques (05 Hrs)

Basic concepts of antigen-antibody interactions (epitope-paratope), Affinity and avidity, cross reactivity, precipitation, agglutination, immunodiffusion, immune-electrophoresis, ELISA (indirect, sandwich, competitive, chemiluminescence, and ELISPOT assay), western blotting, immunofluorescence microscopy, immunohistochemistry and lateral flow assay.

Unit VII: Vaccines and Immunotherapeutics (04 Hrs)

Contributions of Sir Edward Jenner and Louis Pasteur in vaccine development; Major types of vaccine and their characteristics, importance of adjuvants in the development of artificial and active immunity. The concept of passive immunity and immunotherapeutics (Plasma therapy in COVID-19, anti-rabies therapy, anti-toxin therapy), National immunization programme

Unit VIII: Diet, Nutrition and Life style in promoting health and Immunity (09 Hrs)

Importance of a well- balanced nutrition, the role of Immunity boosters and immunomodulators from kitchen shelf (curcumin , ginseng, lycopene &Giloy), vitamins (Vitamin A, B, C, D and Vitamin B12) and minerals (Zn) in improving health and defense.Role of probiotics, gut microbiota andprebioticsin regulating health and immunity. Role of physical activity and emotional & Mental state in regulation of Immunity status, holistic health and happiness. A primer on our traditional practices, yogic lifestyle and meditation in creating homeostasis in the body (balancing Vatta, Pitta and Kapha) will also be given.

Practical component (30 Hours)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Visualization of antigen-antibody interaction or To perform Immuno-diffusion by Ouchterlony method
2. To perform Immuno-diffusion by Mancini Method
3. To perform Complement fixation assay
4. To perform sandwich dot ELISA
5. To perform Widal test (Indirect/passive agglutination) for the detection of typhoid antigen and blood group determination (direct agglutination)

6. To perform SARS-CoV-2 Rapid Antigen Test(Lateral flow Assay)
7. Project work based on historical research work in the area of immunology.
8. Case studies on hypersensitivity reactions(seafood hypersensitivity, Erythroblastosis Fetalis)

Essential readings:

- Punt, J. Stranford, S. Jones, P. and Owen, J. (2019). 8th Edition. *Kuby Immunology*. New York, USA: W.H. Freeman and Company. ISBN- 13: 978-1464189784.
- Delves, P.J. Martin, S.J. Burton, D.R. and Roitt, I. M. (2017). 13th Edition. *Roitt's Essential Immunology*. New Jersey, USA: Wiley-Blackwell Science. ISBN: 13: 978- 1118415771.

Suggestive readings:

- Ananthanarayan R and Jayaram Paniker CK (Author), Reba Kanungo (Editor) (2020) Ananthanarayan and Paniker's Textbook of Microbiology, Eleventh Edition. Universities Press (India) Pvt. ISBN **9389211433**
- Practical Ayurveda: Find Out Who You Are and What You Need to Bring Balance to Your Life Paperback – 5 June 2018 by Sivananda Yoga Vedanta Centre. Publisher : DK; Illustrated : edition (5 June 2018) ISBN-10 : ISBN-13 ,1465468498 978-1465468499.
- Willey, J. Sherwood, L and Woolverton, C.J. (2016). 10th Edition. *Prescott's Microbiology*. New York, USA: McGraw-Hill Education. ISBN-13:978-1259281594.
- Satomi Oshima; Zhen-Bo Cao; Koichiro Oka (2015) 'Physical Activity, Exercise, Sedentary, Behavior and Health' Springer Tokyo Heidelberg New York Dordrecht London ISBN 978-4-431-55333-5 (eBook)
- Guglielmo M Trovato (2012) Behavior, nutrition and lifestyle in a comprehensive health and disease paradigm: skills and knowledge for a predictive, preventive and personalized medicine. Trovato EPMA Journal 2012, 3:8 (Review Article)
- Kindt T. J., Osborne B. A. , Goldsby R. A. (2007). 6th Edition *Kuby Immunology*. New York, USA: W.H. Freeman and Company. ISBN-13: 978-1429202114 ISBN-10: 1429202114.
- Hay, F.C. and Westwood, O.M.R. (2002). 4th Edition. *Practical Immunology*. New Jersey, USA: Blackwell Science. ISBN:9780865429611
- BYG-002 Yoga and Health, Block 4 Yogic Lifestyle, School of Health Science, Indira Gandhi National Open University (https://drive.google.com/file/d/10j00rWXLsCEV5cTbzK-hM43ezlNvn0hl/view)

GENERAL ELECTIVE -10 (BIOMED-GE -10): UNDERSTANDING THE HUMAN BODY SYSTEMS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Understanding The Human Body System BIOMED-GE-10	4	3	-	1	XII Passed	Basic knowledge of Biology

Learning Objectives

The Learning Objectives of this course are as follows:

- This is an introductory course dealing with the structure and function of the human organism and the issues facing the human in today's world.
- It is intended for students with limited science background. It would make them familiar with basic physiological concepts.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Students will have an increased understanding and appreciation for the workings of the human body. They will be familiar with the terminology and physiology of the major organ systems
- They will be able to explain the relation between form and function in biology, as expressed in molecular, cellular, and whole-organism physiology.
- Students will be able to recognize the anatomical structures and explain the physiological functions of the body systems.
- Recognize the anatomical structures and explain the physiological functions of the body systems. Develop scientific terminology to describe the parts and processes of the human body.

SYLLABUS OF BIOMED-GE-10:

Unit I: Body organization and Integumentary system (05 Hrs)

General Anatomy of the body, Introduction to various kinds of body planes, cavities and their membranes, Tissues level of organization and classification (Types, origin, function & repair). Structure and functions of human skin. Blood as connective tissue

Unit II: Nervous System (06 Hrs)

Organization of the Central and Peripheral nervous system. Motor and sensory physiology. Nerve Physiology and Sensory Physiology (Special Senses)

Unit III: Muscular and Skeletal System (04 Hrs)

Functional anatomy of muscular system, types of muscles, neuromuscular junction structure property and transmission, General characteristics of muscle contraction using skeletal muscle as example.

Unit IV: Cardiovascular and Respiratory System (06 Hrs)

Functional Anatomy of heart, The Cardiac Cycle, Electrocardiogram.

Circulatory system: Blood vessels, hemodynamics and regulatory mechanisms.

Lymphatic circulation - hemodynamics and regulation, micro-circulation

Functional Anatomy of the respiratory system. Mechanisms of pulmonary and alveolar, gaseous exchange, transport of gases, respiratory and nervous control and regulation of respiration.

Unit V: Endocrine System (06 Hrs)

General mechanism of hormone action, Structure, function and regulation of the major gland of the body: Pituitary, Hypothalamus, Thyroid, Pancreas and Adrenals. Basic concepts about hypo and hyper secretion of hormones.

Unit VI: Gastrointestinal system (06 Hrs)

Anatomy and histology of the digestive tract. General principles of gut motility secretion, digestion, absorption and assimilation.

Unit VII: Renal Physiology (06 Hrs)

Functional anatomy of kidney, histology of nephron and its physiology, process of urine formation. Urinary bladder: structure, micturition and its regulation

Unit VII: Reproductive System (06 Hrs)

Structure and function of male and female reproductive organs. Basic concepts of gametogenesis (oogenesis and spermatogenesis), fertilization, implantation, menopause and contraception.

Practical component **(30 Hrs)**

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. To prepare a blood smear and identify different types of white blood cells.
2. Estimation of hemoglobin (Sahli's method)
3. Physiological data acquisition based experiments (ECG/PFT/EMG).
4. Blood Pressure recordings in humans.
5. To study a simple reflex arc
6. To study the sensation of taste, touch and smell.
7. To study various types of contraceptives (condoms, IUD"s, oral and injectable contraceptives)
8. To study different human organs and their sections through permanent histological slides T.S. of brain, spinal cord, skeletal fibers, cardiac muscles, skeletal muscles, T. S. of thyroid, liver, thymus, spleen, ovary, artery, vein, capillaries, testis, pancreas, esophagus, adrenal, kidney (cortex and medulla), urinary bladder, fallopian tubes, epididymis, lungs, trachea, heart.(Minimum 8 slides covering the systems mentioned in theory.)

Essential readings:

- Guyton and Hall Textbook of Medical Physiology, 14th edition (2020), J. E. Hall; W B Saunders and Company, ebook ISBN: 978-0-3236-4003-9; Hardcover ISBN: 978-0-3235-9712-8
- Principles of Anatomy and Physiology, 16th edition (2020), Gerard J. Tortora and Bryan H. Derrickson; Wiley and Sons, ISBN: 978-1-119-66268-6. (e book), ISBN: 978-1-119-70438-6 (for print book).
- Textbook of Practical Physiology, 9th edition (2019), CL Ghai; Jaypee Publication, ISBN-9789352705320.
- Human Physiology, 16th edition (2011), Stuart I. Fox; Tata McGraw Hill, ISBN10: 1260720462; ISBN13: 978-1-26-072046-4.

Suggestive readings:

- Ganong's Review of Medical physiology, 26th edition (2019), K. E. Barett, S. M. Barman, S. Boitano and H. Brooks; Tata McGraw Hill, ISBN 978-1-26-012240-4 (for ebook) ISBN:978-1-26-012241-1 (for print Book)

GENERAL ELECTIVE -11 (BIOMED-GE -11): DRUGS AND VACCINES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Drugs and Vaccines **BIOMED-GE-11**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of Biology**

Learning Objectives

The Learning Objectives of this course are as follows:

- This course integrates the concept of chemistry, biochemistry, pharmacology and immunology for understanding the process of drug action in the body.
- The focus is on various targets present in body that can be useful in rational drug design.
- The course entails different approaches to drug discovery and design, sources of drugs and measurement of drug target interaction.
- It also aims to understand the human immune system and the immunotherapies used to combat disease.

Learning outcomes

The Learning Outcomes of this course are as follows: Having successfully completed this course, students shall be able to learn and appreciate:

- The student will understand the concept of drugs and vaccines, their effect on body and different routes used to administer them in body.
- They will be able to identify the various drug targets in the body
- Students will learn to identify various parameters for comparison of different drugs with ways to analyse how safe a drug is for use. Also, they will understand the overall process of drug design, various approaches used in drug discovery and the concept of rational drug design. They will also learn about mode of action of different types of Drugs
- Students will also learn about the Organization, Properties and Functioning of the Immune System. Innate and adaptive immune responses. Antigen-antibody interactions.

- Students will familiarize themselves with the need for vaccines, concepts and principles of vaccines, types of vaccines and available vaccines: BCG, DPT, HBV, HPV, Polio, Covid-19. Finally, the student will be able to grasp the use of immuno-therapeutics in dealing with certain infections rabies vaccine, plasma therapy) and the concept of using antibodies as drug carriers.

SYLLABUS OF BIOMED-GE- 11

Unit-I: Introduction of Drugs (06 Hrs)

Definition and scope of Drugs, source of drugs, routes of drug administration and their advantages anddisadvantages (with emphasis on oral and I.V), Bioavailability and first pass metabolism, drug formulations and delivery agents. Introduction to pharmacodynamics and pharmacokinetics (brief introduction on ADME)

Unit-II: Drug Target Classification and Measurement of Drug Receptor Interactions (10 Hrs)

Classification of Drug targets: Proteins, Nucleic acid, lipids and carbohydrates

Proteins as drug targets: Receptors: Receptor role, Ion channels, membrane bound enzyme activation, concept of Agonist, antagonists, partial agonist (Cholinergic agonist and antagonist, Dopaminergic agonist and antagonist)

Enzymes: Enzyme inhibitors (competitive, non- competitive (ethylene glycol for antifreeze poisoning, ACE inhibitor, Aspirin, 6-mercapto purine)

Analysis of ligand receptor interaction, relationship between dose and effect (graded and quantal response). Affinity, Efficacy and potency, therapeutic index.

Unit-III: Drug Design and Mechanism of Action of Drugs (07 Hours)

Introduction to Drug design, Analogue synthesis versus rational drug design, Strategies in the search for new lead compounds (random and non-random screening), SAR, Concept of prodrugs (to tackle toxicity and membrane permeability)

Mode of action of following class of drugs: Antipyretics (Paracetamol), Anti-inflammatory drugs (Ibuprofen), Anticancer drugs (cisplatin), Antibiotics and Antibacterial drugs (sulphonamides, Penicillin), Antifungal drugs (Amphotericin B).

Unit-IV: Introduction to the Immune System (12 Hours)

Historical background, organization of the immune system, lymphoid organs: Bone marrow, thymus, lymph nodes and spleen.

Innate Immune System: Physical and chemical barriers, brief overview of the cells of the innate immune system: Natural Killer cells, monocytes and macrophages; neutrophils, eosinophils, basophils, mast cells and dendritic cells, Mechanisms of pathogen killing by phagocytes: macrophages and neutrophils, Inflammation: brief overview

Adaptive Immune System: Cells of the adaptive immune system: B and T lymphocytes: characteristics viz; Specificity, diversity, immunologic memory, self and nonself recognition. B cell and T cell development, Antigens: Properties: foreignness, molecular size, route and dose of administration, Antibodies: Structure, classes and distribution, B cell and T cell epitopes, MHC molecules: structure and functions, Antigen processing and presentation on MHC molecules

Unit V: Vaccines and Immuno-therapeutics (10 Hours)

Principles and concepts of vaccines: History of vaccines- Contribution of Sir Edward Jenner and Louis Pasteur I n vaccine development. Major types of vaccines and their characteristics: while cell based vaccines, subunit based vaccines, vectored vaccines, nucleic acid based vaccines. Importance of adjuvants in development of artificial and active immunity.

Common vaccines: BCG, DPT, HBV, HPV, Polio, Covid-19. Immuno-therapeutics: Rabies Vaccine and Plasma therapy. Antibody and receptors as drug carriers and targets. National immunization program.

Practical component (30 Hours)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. To study different routes of administration of drugs.
2. To study the presence of acetaminophen in a given sample.
3. Quantitative estimation of acetaminophen in a given sample using spectrophotometer.
4. Extraction of caffeine from tea leaves.
5. Study the absorption properties of caffeine using spectrophotometer

6. Phytochemical screening and qualitative chemical examination of various plant constituents by solvent extraction. (Detection of alkaloids, carbohydrates, glycosides, phytosterols, oils and fats, tannins, proteins, gums).
7. To record CRC of acetylcholine using guinea pig ileum/ rat intestine (virtually)
8. Study of competitive antagonism using acetylcholine and atropine.
9. Determination of dose ratio.
10. To perform blood grouping (direct agglutination)
11. To perform Widal test (indirect agglutination).

Essential readings:

- Punt, J. Stranford, S. Jones, P. and Owen, J. (2019). 8th Edition. Kuby Immunology. New York, USA: W.H. Freeman and Company. ISBN- 13: 978-1464189784.
- Patrick G.I. (2017). 6 th Edition. Introduction to medicinal chemistry. Oxford, UK: Oxford University Press. ISBN-13: 978-0198749691.
- Silverman, R.B. and Holladay, M.W. (2014). 3 rd Edition. The organic chemistry of drug design and drug action. San Diego, USA: Elsevier, Academic Press. ISBN-13: 9780123820303.

Suggestive readings:

- Wermuth, C.G., Aldous, D., Raboisson, P. and Rognan, D. (2015). 4 th Edition. The practice of medicinal chemistry. San Diego, USA: Elsevier, Academic Press. ISBN-13: 978-0124172050.
- Nogrady, T. and Weaver, D.F. (2005). 3rd Edition. Medicinal chemistry: A molecular and biochemical approach. New York, USA: Oxford University Press. ISBN-13: 978-0195104561.
- King F.D. (2003). 2 nd Edition. Principles and practice of medicinal chemistry. London, UK: The Royal Society of Chemistry. ISBN-13: 978-0854046317.
- Hay, F.C. and Westwood, O.M.R. (2002). 4th Edition. Practical Immunology. New Jersey, USA: Blackwell Science. ISBN: 9780865429611.
- Gringauz, A. (1996). 1 st Edition. Introduction to medicinal chemistry: How drugs act and why. Brooklyn, New York, USA: Wiley VCH. ISBN-13: 978-0471185451.

SEMESTER- VI

B.Sc (Hons.) Biomedical Science

Discipline Specific Core Course (BIOMED-DSCs)

DISCIPLINE SPECIFIC CORE COURSE -16 (BIOMED-DSC-16) BIOPHYSICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Biophysics BIOMED-DSC-16	4	3	-	1	XII Pass with Physics, Chemistry & biology	Basic knowledge of Bio- physical Techniques

Learning objectives

The Learning objectives of this course are as follows:

- The course will demonstrate the role of fundamentals of chemistry and physics in understanding the biological processes including the methods to study the structure and functions of macro molecules and the chemical reactions occurring in living cells.
- The students will be able to learn theoretical basis of various analytical and biomedical techniques including various spectroscopic techniques, hydrodynamic methods, molecular biophysics.
- The students will be introduced to various physical principles responsible for maintaining the basic cellular function and integrity of biological membranes including transport across them.

Learning outcomes

Having successfully completed this course, students shall be able to learn and appreciate:

- The interdisciplinary frontier of science in which the principles and techniques of physics are applied to understand biological problems at every level, from atoms and molecules to cells, organisms and environment and analyze the data generated through spectroscopic techniques such as UV-Visible, Infrared, Mass spectroscopy, NMR, etc.
- Understand the concepts of viscosity and sedimentation methods and their biological applications.
- Comprehend the thermodynamics of the structure of biomolecules and consequences of their structural instability and apply their biophysics knowledge to analyze the known experiments and to develop newer experimental methods for new biophysical applications.

- Understand the physical basis of transport across biological membranes. Additionally, they will be able to perform the experiments and demonstrate the interpretation of the data and further be able to deliver scientific conclusions. Further, they can apply their biophysics knowledge to analyze the known experiments and to develop newer experimental methods for new biophysical applications.

SYLLABUS OF BIOMED-DSC-16

Unit-I: Basic Spectroscopic Techniques (10 hrs)

Basic principles of electromagnetic radiation: Energy, wavelength, wave numbers and frequency, Review of electronic structure of molecules.

UV-visible spectrophotometry: Beer Lambert law, Light absorption and its transmittance, Factors affecting absorption properties of achromophore, Structural analyses of DNA/protein using absorption of UV light.

Fluorescence spectroscopy: Theory of fluorescence, Static and dynamic quenching, Resonance energy transfer, Fluorescent probes in the study of protein and nucleic acids.

Infra-red spectroscopy: Theory of IR, Identification of exchangeable hydrogen, Number of hydrogen bonds, Tautomeric forms, Biological significance of IR.

Unit II: Advanced Biophysical Techniques (10 hrs)

Optical rotatory dispersion and Circular dichroism: Principle of ORD and CD, Analysis of secondary structure of proteins (denatured and native form) and nucleic acids using CD.

Magnetic resonance spectroscopy: Basic theory of NMR, Chemical shift, Medical applications of NMR.

Mass Spectrometry (MALDI-TOF): Physical basis and uses of MS in the analysis of proteins/nucleic acids.

X-ray crystallography: Diffraction, Bragg's law and electron density maps (concept of R-factor and B-factor), Growing of crystals (Hanging drop method), Biological applications of X-ray crystallography.

Unit-III: Hydrodynamic Methods (10 hrs)

Viscosity: Methods of measurement of viscosity, Specific and intrinsic viscosity, Relationship between viscosity and molecular weight, Measurement of viscoelasticity of DNA.

Sedimentation: Physical basis of centrifugation, Svedberg equation, Differential and density gradient centrifugation, Preparative and analytical ultracentrifugation techniques, Fractionation of cellular components using centrifugation with examples.

Flow Cytometry: Basic principle of flow cytometry and cell sorting, Detection strategies in flow cytometry.

Unit-IV: Molecular Biophysics (7 hrs)

Basic thermodynamics: Concept of entropy, enthalpy, free energy change, heat capacity. Forces involved in biomolecular interactions with examples: Configuration versus conformation, Vander Waals interactions, Electrostatic interactions, Stacking interactions, Hydrogen bond and hydrophobic effect, Ramachandran plot.

Supercoiling of DNA: Linking number, twist and writhe.

Protein folding: Marginal stability of proteins, Thermodynamic and kinetic basis of protein folding.

Unit-V: Biological Membranes **(8 hrs)**

Biophysical basis of transport of solutes and ions, Fick's laws of diffusion, Transport equation, Membrane potential, an introduction to ionophores.

Practical **(30 hrs)**

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Effect of different solvents on UV absorption spectra of proteins.
2. Study of structural changes of proteins at different pH using UV spectrophotometry.
3. Study of structural changes of proteins at different temperature using UV-spectrophotometry.
4. Determination of melting temperature of DNA.
5. Study the effect of temperature on the viscosity of a macromolecule (Protein/DNA).
6. Use of viscometer in the study of ligand binding to DNA/protein.
7. Crystallization of enzyme lysozyme using hanging drop method.
8. Analysis, identification and comparison of various spectra (UV, NMR, MS, IR) of simple organic compounds.

Essential readings

- Skoog D.A., Holler, F.J. and Crouch, S.R. (2017). 7thEdition. Principles of Instrumental Analysis. Boston, USA: Cengage Learning. ISBN-13:978-1305577213.
- Sheehan, D. (2009). 2nd Edition. Physical biochemistry: Principles and applications. Oxford, UK: JohnWiley.ISBN-13:978-0470856031.
- Freifelder, 1983). 2nd Edition. Physical biochemistry: Applications to biochemistry and molecular biology. NewYork, USA: W.H. Freeman and Company. ISBN-13:978-0716714446.

Suggestive readings

- Hofmann, A. and Clokie, S. (2018). 8th Edition. Wilson and Walker's principles and techniques of biochemistry and molecular biology. Cambridge, UK: Cambridge University Press. ISBN: 978-1108716987.

- Watson, J.D., Baker T.A., Bell, S.P., Gann, A., Levine, M., Losick, R.(2013).7th Edition. Molecular Biology of the Gene. New York, USA: Cold Spring Harbor Laboratory Press, ISBN-13:978-0321762436.
- Tinoco I., Sauer, K. Wang, J.C., Puglisi, J.D., Harbison, G. and Rovnyak, D. (2013). 5thEdition. Physical chemistry: Principles and applications in biological sciences Pearson, Prentice Hall. ISBN-13:978-0136056065.
- Kuriyan, J., Konforti, B. and Wemmer, D. (2012). 1st Edition. The molecules of life: Physical and chemical principles. New York, USA: Garland Science. ISBN-13: 978-0815341888.
- Frauen felder, H., Chan, S.S. and Chan, W.S. (2010). 1stEdition. The physics of proteins: An introduction to biological physics and molecular biophysics. NewYork, USA:Springer, ISBN-13: 978-1441910431.
- Rhodes, G. (2006). 3rd Edition. Crystallography made crystal clear: Guide for users of macro molecular models. Massachusetts, USA: Academic Press. ISBN-13:978-0125870733.
- Van Holde, K.E., Jhonson, W.C. and Shing Ho, P. (2005). 2nd Edition. Principles of physical biochemistry. NewJersey, USA: Prentice Hall Inc.ISBN-13:978-0130464279
- Branden, C. and Tooze, J. (1999). 2nd Edition. Introduction to protein structure. New York, USA: Garland Science, ISBN-13: 978-0815323051.
- Hoppe, W., Lohmann, W., Markl, H. and Ziegler, H.(1983). 1st Edition. Biophysics. Berlin, Germany: Springer-Verlag and Heidelberg GmbH & Co., ISBN-13:978-3540120834.
- Cantor, C.R. Schimmel, P.R. (1980). 1st Edition. Biophysical Chemistry. New York, USA: W.H. Freeman and Company. ISBN-13:9780716711889.

DISCIPLINE SPECIFIC CORE COURSE- 17 (BIOMED-DSC-17) HUMAN GENETICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Human Genetics BIOMED-DSC-17	4	3	-	1	XII Pass with Physics, Chem & biology	Basic Knowledge of Genetics

Learning objectives

The Learning objectives of this course are as follows:

- This course is designed to develop an appreciation for the groundwork carried out so far in areas that contributed to our understanding of human genetics and diseases, relates to how it has been built on the numerous genetic studies carried out over decades to contribute to the understanding of the relationship between genotype and phenotype.
- The course will also introduce the sequencing of the Human Genome and new methods of investigating biological function, research into the genetic and molecular basis of human disease.

Learning outcomes

Having successfully completed this course, students shall be able to:

- Students will understand the patterns of inheritance of monogenic traits from pedigree data for both Mendelian and non-Mendelian traits.
- They will comprehend the techniques and advances in the analysis of DNA, identification of genes involved in diseases, and gene/sequence mapping strategies.
- Students will be able to describe objectives, tools, approaches and outcomes of the Human Genome Project (HGP). They will be aware of the ethical and societal issues raised by the new knowledge derived by using new technologies.
- Students will be able to apply principles of genetics at population level.
- They will understand the genetic basis of common diseases and methods of prenatal diagnosis.
- Students will be able to proficiently explore relevant literature, web sites and databases for research into human genetics.

SYLLABUS OF BIOMED-DSC-17:

Unit- I: Inheritance for Monogenic Traits (08 hrs)

History of Human Genetics: Early Greek concepts about inheritance, Cytogenetics history (the works of Winiwater, Painter and Tjio and Levan), Landmark achievements of Galton, Garrod etc. Patterns of Inheritance: Recapitulation of principles of human inheritance pattern through pedigree analysis: Autosomal inheritance-dominant, recessive, sex-linked inheritance, sex- limited and sex- influenced traits and mitochondrial inheritance. Deviations from the basic pedigree patterns- non-penetrance, variable expressivity, pleiotropy, late onset, anticipation, consanguinity and its effects, mosaicism and chimerism, genetic heterogeneity, uniparental disomy, and genomic imprinting.

Unit- II: Genetic and Physical Maps (06 hrs)

Genetic markers and their applications. Overview of genetic maps. Physical maps (different types- restriction, cytogenetic maps, use of FISH in physical mapping, radiation hybrids and clone libraries in STS mapping)

Unit- III: Identification of Human Disease Genes (08 hrs)

Principles and strategies, positional and candidate gene approaches, (examples- HD, CFTR), concept of twin and adoption studies.DNA sequencing (Principles of Maxam-Gilbert and Sanger Method, introduction to NGS with an example of illumina based sequencing), DNA fingerprinting, polymorphism screening (genotyping of SNPs and microsatellite markers)

Unit- IV: Human Genome Project (04 hrs)

History, organization and goals of human genome project, Tools (Vectors- BAC, PAC, YAC)) and approaches (Hierarchical and whole genome shotgun sequencing), outcomes ethical issues and applications in human diseases

Unit- V: Population Genetics (05 hrs)

Genotypic and allelic frequencies, Hardy-Weinberg Equilibrium, linkage disequilibrium, haplotype construction (two loci using SNPs and/or microsatellites).

Unit- VI: Clinical Genetics (08 hrs)

Inborn errors of metabolism and their genetic basis (example- phenylketonuria), genetic disorders of hematopoietic systems (examples- sickle cell anemia and thalassemia), genetic basis of color blindness, familial cancers (example- retinoblastoma) and mental retardation.

Prenatal Diagnosis: Brief introduction, methods of prenatal diagnosis (invasive and non-invasive such as Amniocentesis, Chorionic villus sampling, Ultrasonography, Fetoscopy, Maternal serum screening, Fetal cells in maternal blood) and its application with examples of Aneuploidy and Thalassemia.

Pharmacogenetics and Pharmacogenomics(genetic polymorphism in drug metabolism genes e.g. cytP450 and GST and their effect on drug metabolism and drug response), genetic counseling.

Unit- VII: Guided short project (06 hrs)

Short project involving, data analysis/*in silico* analysis of genomes/ literature-based project; guiding the students through identification of the project, discussions on approach and methodology, and strategies for data analysis.

Practical (30 hrs)

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Pedigree construction of some common phenotypic characteristics of humans.
2. Pedigree analysis and risk assessment.
3. Restriction mapping/ STS mapping from the given data.
4. Demonstration of DNA fingerprinting.
5. Polymorphism analysis using PCR.
6. Analysis of the given DNA sequencing data based on Maxam-Gilbert and Sanger sequencing methods.
7. Study of Hardy-Weinberg equilibrium by PTC tasting and ABO blood grouping.
8. Video based demonstration of tools for prenatal diagnosis.
9. Exploring DNA, RNA, and Protein Sequence Databases for retrieval of a desired human sequence and sequence alignment using BLAST.
10. Preparation of human metaphase chromosomes and Giemsa staining.

Essential readings:

- Strachan, T. and Read, A. (2018). 5th Edition. *Human molecular genetics*. Florida, USA: CRC Press, Garland Science. ISBN: 978-0815345893.
- Pasternak, J.N. (2005). 2nd Edition. *An introduction to human molecular genetics*. New York, USA: Wiley-Liss. ISBN: 978-0-471-47426-5.

- Cantor, C.R. and Smith, C.L. (1999). 1st Edition. *Genomics: The science and technology behind the human genome project*. New York, USA: Wiley-Interscience. ISBN: 9780471599081.

Suggestive readings:

- Brown, T.A. (2023). 5th Edition. *Genomes 4*. New York, USA: Garland Science. ISBN-13: 978-0815345084.
- Speicher, M.R., Antonarakis, S.E. and Motulsky, A.G. (2010). 4th Edition. *Vogel and Motulsky's Human genetics: Problems and approaches*. Berlin, Germany: Springer Verlag. ISBN: 978-3540376538.
- Wilson, G.N. (2000). 1st Edition. *Clinical genetics: A short course*. New York, USA: Wiley-Liss, ISBN: 978-047129806.

DISCIPLINE SPECIFIC CORE COURSE- 18 (BIOMED-DSC-18) TOXICOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Toxicology BIOMED-DSC-18	4	3	-	1	XII Pass with Physics, Chemistry & biology	Basic Knowledge of Pharmacology

Learning objective

- The present course content is designed to provide the basics of toxicology. The course would help to understand the influence of toxic substances on various body organs. It provides insight into measurement of toxicity, principles of exposure, molecular mechanism of toxicity and toxicants that harm our environment.
- Relevant importance has been given to those topics which can build a strong foundation in the subject, based on which, facts can be assimilated during subsequent higher studies.

Learning outcomes

- Familiarity with the form of toxicology practiced during antiquities across the world; and how the modern form of toxicology emerged. Nature of toxic substances and how humans are exposed to them. Spectrum of toxic responses. Types of toxicity and factors affecting the toxicity by a chemical.

- Basics methods and biological parameters used to measure toxicity of a chemical. General mechanisms whereby toxicants cause toxicity; interaction of toxicants with target bio-molecules in the body and resultant toxicity. Basics of safety evaluation of toxicants.
- Mechanisms/processes involved in absorption, transport, chemical modification and excretion of toxicants from the body.
- Through examples of few common classes of toxicants such as pesticides and metals, students are able to learn; how humans are exposed to them, their mechanism of action and symptoms of toxicity.
- The process by which certain anthropogenic chemicals cause harm to wildlife/ ecosystem.
- Basics of management, clinical evaluation of toxic patients, methods used to prevent further toxicity, and use of antidotes.

SYLLABUS OF BIOMED-DSC-18

Unit-I: Introduction (07hrs)

Brief history, Different areas of modern toxicology, Classification of toxic substances, various definitions of toxicological significance, characteristic and types of toxic responses and tolerance to toxicants.

Unit-II: Toxic exposure, response, evaluation of toxicity and mechanism of toxicity (14hrs)

Effect of duration, frequency, route and site of exposure of xenobiotics on its toxicity, various types of dose response relationships, assumptions in deriving dose response, LD50, LC50, TD50, NOAEL, ADI, MOE and therapeutic index. Concept of ultimate toxicant, general mechanisms by which various toxicants cause toxicity (up to molecular and cellular level).

Unit-III: Fate of xenobiotics in human body (12 hrs)

Absorption, distribution, excretion and metabolism of xenobiotics (biotransformation, Phase-I reactions including oxidations, hydrolysis, reductions and phase II conjugation reactions). Toxic insult to liver, its susceptibility to toxicants with reference to any two hepatotoxicants.

Unit-IV: Toxic agents (06hrs)

Human exposure, mechanism of action and resultant toxicities of the following xenobiotics: Metals: lead, arsenic; Pesticides: organophosphates, bipyridyl compounds and anticoagulant pesticides.

Unit-V: Eco-toxicology (02hrs)

Brief introduction to avian and aquatic toxicology, movement and effect of toxic compounds in food chain (DDT, mercury), concept of bio-accumulation, bio-magnification.

Unit-VI: Clinical toxicology **(04hrs)**

Management of poisoned patients, clinical methods to decrease absorption and enhance excretion of toxicants from the body, use of antidotes.

Practical **(30 hrs)**

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Separation of a mixture of benzoic acid, beta- naphthol and naphthalene by solvent extraction and
2. Identification of their functional Groups.
3. Determination of Dissolved oxygen (DO) using Winkler method.
4. Determination of Biological oxygen demand (BOD) of water.
5. To perform quantitative estimation of residual chlorine in water samples.
6. To determine the total hardness of water by complexo-metric method using EDTA.
7. To determine acid value of the given oil sample.
8. To estimate formaldehyde content of given sample.
9. Calculation of LD50 value of an insecticide from the data provided.
10. Determination of COD (chemical oxygen demand) of the given water sample.

Essential reading

- Klaassen, C.D and Watkins, J.B. (2021). 4th Edition. *Casarett and Doull's Essentials of Toxicology.* McGraw Hill, ISBN-13: .1260452297-978
- Klaassen, C.D. (2018). 9th Edition. *Casarett and Doull's Toxicology, The Basic Science of the Poisons.* McGraw Hill. ISBN-13: 978-1259863745.

Suggestive readings

- Stine, K.E. and Brown T.M (2015). 3rd Edition. *Principles of Toxicology.* Florida, USA: CRC Press. ISBN-13: 9781466503434.
- Timbrell. J. (2001). 3rd Edition. *Introduction to Toxicology.* CRC Press. ISBN-13: 978-0415247634.

Pool of DSEs

DISCIPLINE SPECIFIC ELECTIVE COURSE– 10 (BIOMED-DSE-10)
FUNDAMENTALS OF NEUROSCIENCE

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the Course	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Fundamentals of Neuroscience BIOMED-DSE-10	4	3	-	1	XII Pass with Physics, Chemistry & biology	Basic knowledge of Physiology, biochemistry and Cell biology	Biomedical Science

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide a comprehensive overview of the basic principles and concepts in neuroscience, including the structure and function of the nervous system, neural communication, and basic neuroanatomy.
- The paper aims to investigate the neural mechanisms underlying a particular phenomenon, such as perception, memory, learning, decision-making, or emotion.
- To prepare students to undertake further research in the area of neuroscience.

Learning outcomes

Having successfully completed this course, students shall be able:

- To understand the fundamental organization, function and development of the nervous system.
- To conceptualize and compare the role of different neurotransmitters.
- To understand the mechanisms of different disorders associated with the nervous system.
- To appreciate the principles and applications of different tools and techniques used in neuroscience.
- To proficiently explore relevant websites and databases related to latest initiatives in the field of neuroscience.

SYLLABUS OF BIOMED-DSE-10

Unit I: Introduction to Neuroscience (10hrs)

Brief overview of Neuroanatomy: Timeline of the nervous system development, Organization of Central Nervous System (CNS), Peripheral Nervous System (PNS), Autonomic Nervous System (ANS). Meninges and Cerebrospinal Fluid (CSF), Vascular Supply of the Brain: blood brain barrier and blood CSF barrier.

Unit II: Neurochemistry and Neurophysiology (10hrs)

Introduction to Neurochemistry, overview of synaptic transmission and cellular signaling. Neurotransmitters and their receptors: Acetylcholine, Glutamate, GABA, Dopamine, Serotonin and Epinephrine. Neuropeptides, Gut-Brain axis. Membrane potentials, Post synaptic potential and synaptic integration, Neuromuscular junctions.

Unit III: Brain and Behavior (06 hrs)

Neuroplasticity, learning and memory, cognition, sleep, circadian rhythm, Affective immunology: emotions and Immunity

Unit IV: Diseases of the nervous system (10hrs)

Overview of neuroinflammation, Neurochemical and molecular mechanisms of different neurological conditions: Autism, Attention Deficit Hyperactivity Disorder (ADHD), Epilepsy, Anxiety and depression, Alzheimer Disease, Parkinson Disease/ Schizophrenia, and Amyotrophic Lateral Sclerosis (ALS)

Unit V: Tools and Techniques in Neuroscience / Kaleidoscopic Dimensions of Neuroscience(09hrs)

Methods and tools to study brain and behavior: neuroimaging techniques (MRI, PET), electrophysiological studies (EEG). *In vitro* models of neurosciences including cell culture, tissue culture and animal models. Introduction to Neuroinformatics.

Practical (30 hrs)

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Gross examination of the brain and its different parts (human and animal) through videos.
2. Histology of different brain sections through permanent slides.
3. Microanatomy of neurons using virtual labs.
4. Electrophysiological studies using physiological data acquisition systems (teaching modules)

5. Exploration and extraction of information about the brain from NCBI, NIF, Allen Brain Atlas, the virtual brain, Human Connectome Project, etc.
6. Behavioral studies using virtual lab- Motor functions tests (Rotarod Test, Grip Strength Test), Cognitive Functions tests – Learning and memory related test (Water Maze, open field test, etc.)

Essential readings:

- Kandel, E. R., Koester, J. D., Mack, S.H., et al. (2021). 6th Edition. Principles of Neural Science. McGraw Hill, ISBN: 978-1259642234
- Sontheimer, H. (2021). 2nd Edition. Diseases of the Nervous System. Elsevier, ISBN: 978-0128212288
- Squire, L., Spitzer, N. C., Berg, D., et al. (2012). 4th Edition. Fundamental Neuroscience, Academic Press, ISBN: 978-0123858702
- Brady, S. T., Siegel, G. J., Albers, R. W., et al. (2011). 8th Edition. Basic Neurochemistry. Academic Press, ISBN: 0125468075
- Zigmond, M. J., Bloom, F. E., Roberts, J. L., et al. (2008). 3rd Edition. Fundamental Neuroscience. Academic Press, ISBN: 978-0123740199

Suggested readings:

- Sanes, D. H., Reh, T. A., Harris, W. A., et al. (2019). 4th Edition. Development of the Nervous system. Academic Press, ISBN: 978-0128039960
- Gilbert, S. F., & Barresi, M. J. F. (2016). 11th Edition. Developmental Biology. Sinauer Associates Inc, ISBN: 978-1605354705
- Hall, J.E. (2015). 13th Edition. Guyton and Hall textbook of Medical Physiology. Philadelphia, USA: W B Saunders and Company. ISBN-13: 978-1455770052
- Aminoff, M., Greenberg, D., Simon, R. P. (2015). 9th Edition. Clinical Neurology. McGraw Hill Education, ISBN: 978-0071841429

DISCIPLINE SPECIFIC ELECTIVE COURSE –11 (BIOMED-DSE-11) GREEN CHEMISTRY METHODS IN PHARMACEUTICAL AND INDUSTRIAL APPLICATIONS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical /Practice			
Green Chemistry Methods in Pharmaceutical and Industrial Applications **BIOMED-DSE-11**	4	3	-	1	**XII Pass with Physics, Chemistry & biology**	**Basic knowledge of organic reactions**	**Biomedical Science**

Learning objectives

The objective of this course is to make students aware of

- The toxicity, hazard and risk of chemical substances as well as to be aware of the importance of green chemistry in today's world.
- To familiarize students with environment-friendly alternatives for the synthesis of various chemicals.
- ·Course will help to understand the usage of various green approaches in synthetic chemistry and their applications for sustainable development.

Learning outcomes

After studying this course students should be able to:

- Understand the twelve principles of green chemistry and gain an in-depth understanding of chemical toxicity, hazard, and associated risk.
- Learn to create non-toxic chemicals, products, and processes than current alternatives.
- Comprehend the importance of inherently safer design for accident prevention
- ·Understand the advantages of using catalysts and biocatalysts, use of renewable feedstocks and green solvents for environmental protection.
- Appreciate the role of green chemistry in innovatively solving environmental issues.
- Green chemistry is a mean to maximize revenues, productivity, and sustainability while producing zero waste. They are also motivated to practice green chemistry by success stories and real-life examples.

SYLLABUS OF BIOMED-DSE-11

Unit I: Introduction to Green Chemistry **(10 hrs)**

Importance of Green Chemistry: Green Chemistry in nature (for example nitrogen fixation, photosynthesis, glucogenesis/ glycolysis), Twelve principles of green Chemistry:Prevention of waste, Atom economy, Designing less hazardous chemical synthesis, Designing safer products, Safer solvents and auxiliaries, Design for energy efficiency, Renewable resources, Reduce derivative, Use of selective catalyst, Design for degradation, You cannot control what you cannot measure, Inherently safer chemistry for accident prevention, Important environmental laws, the Pollution Prevention Act of 1990, Limitations and Obstacles in the Pursuit of the Goals of Green Chemistry.

Unit II: Conventional Chemistry vs Green Chemistry **(10 hrs)**

General concept of mixing of orbitals (Hybridization), Role of various electronic effects in the modulation of reactions; Homolytic and Heterolytic cleavage. Substitution reactions (hydrolysis of alkyl halides and Hydrolysis of esters), Addition reactions (Hydrogenation of alkenes), Elimination reactions (Hoffman elimination, Decarboxylation), Rearrangement (Diels-Alder reactions), Cis-trans isomerisation of alkenes, Condensation reactions: Aldol (replacement of ethanol with solvent free reaction) and Benzoin (replacement of KCN, TPP, Thiamine HCl). Prevention of waste/by-product pollution, calculation of atom economy with reference to above reactions.

Unit III: Green Solvents **(10 hrs)**

- Conventional solvents (Ethanol, Acetone, chloroform, DCM) and Green Solvents (water/buffer, supercritical fluids, ethyl lactate, Ionic liquids). Buffers (Phosphate, Acetate) and buffer action (concept of pKa), Relative acids/basic strength of organic acids and bases (aliphatic and aromatic).
- Advantages of green solvents in chemical synthesis: Supercritical CO_2 in the separation of coffee from coffee beans and perfume industry, water as a green solvent in reactions (Benzoin condensation, Hofmann Elimination, methyl benzoate to benzoic acid and Decarboxylation reaction).
- Ionic liquids: physicochemical properties, Advantages and Disadvantages (purification of complex mixtures and cost), Reactions of Ionic liquids: Imidazolium based ionic liquid for the synthesis of antiviral drug trifluridine, hydrogenation of alkenes, Diels-Alder reaction with copper (II) bisoxazolium complex having imidazolium tag.

Unit IV: Various Approaches to Green reaction synthesis (10 hrs)

- Enzyme-based reactions: Biocatalyst (concept of stereoselectivity and stereospecificity, and turnover number), Biocatalyst mediated synthesis of Sitagliptin drug and ethanol; Nanocatalysis (oxazole synthesis using nanocatalyst). Photocatalysis: Visible light induced Reactions (syntheses of vitamin D3, cis-trans isomerization of alkenes, waste water treatment with TiO2).
- Microwave-assisted green approach: Principle, merits, demerits and effect of solvent; Microwave-assisted reactions: solvent-free synthesis of aspirin, Renewable starting materials: Synthesis and properties of 5-Aminolevulinic acid (DALA) from levulinic acid. Design of degradable reactions (pesticides), Inherently Safer design in chemical synthesis: Principle and Subdivision eg. Bhopal Gas Tragedy.

Unit V: Pharmaceutical and Industrial Applications for revenue, productivity and sustainability (5 hrs)

Vitamin C used in cosmetics/neutraceuticals industry: Synthesis using enzymes, commercial production of drugs/pharmaceutical product: anti-depressant drug sertraline, Removal of Drug from Waste water: Levofloxacin, an anti-bacterial drug with ZnO nanoparticles, Enzymatic synthesis of Zero Trans-Fats and Oils,

Practical: (30 hrs)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.) (Any seven)

1. Preparation and characterization of biodiesel from vegetable oil preferably waste cooking oil.
2. Benzoin condensation using thiamine hydrochloride as a catalyst instead of cyanide
3. Mechanochemical solvent-free synthesis of succinic anhydride/phthalic anhydride
4. Hydrolysis of esters/ esterification using green methods.
5. Solvent-free, microwave-assisted one-pot synthesis of phthalocyanine complex of copper (II).
6. Cross aldol condensation reaction using base catalyzed green method.
7. Microwave-assisted synthesis of drug/ drug intermediates (Knoevenagel reaction, Aspirin)
8. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.
9. Acetylation of primary aromatic amine using the green method.
10. Synthesis of nanoparticles using green approach.

Essential Reading:

- Matlack, A.S., Andraos. J, (2022); Introduction to Green Chemistry, 3rd Edition, CRC press (ISBN: 978-1032199429).

- Sharma, R.K.; Bandichhor, R. (2018), Hazardous Reagent Substitution, Royal Society of Chemistry. (ISBN: 978-1-78262-050-1)
- Lancaster, M. (2016), Green Chemistry: An Introductory Text, 3rd Edition, RSC Publishing. (ISBN: 978-1-78262-294-9)
- Wei Zhang, Berkeley W. Cue Jr (2012) "Green Techniques for Organic Synthesis and Medicinal Chemistry" John Wiley & Sons, Ltd (ISBN:9780470711828)
- Sharma, R.K.; Sidhwani, I.T.; Chaudhari, M.K. (2012), Green Chemistry Experiments: A monograph**,** I.K.International Publishing House Pvt Ltd. (ISBN: 978-9381141557)
- Kirchhoff, M.; Ryan, M.A. (2002), Greener approaches to undergraduate chemistry experiment**.** American Chemical Society, Washington DC. (ISBN: 8412-3866-9)
- Anastas, P.T.; Warner, J.C. (2000), Green Chemistry: Theory and Practice, Oxford University Press. (ISBN: 9780-198506980).
- El-Maraghy, C. M., El-Borady, O. M., & El-Naem, O. A. (2020). Effective Removal of Levofloxacin from Pharmaceutical Wastewater Using Synthesized Zinc Oxid, Graphen Oxid Nanoparticles Compared with their Combination. *Scientific Reports*, *10*(1), Article 1. https://doi.org/10.1038/s41598-020-61742-4

Suggestive readings

- Batra. S.K; Gulati, S; Shukla, S, (2020); Practical Green Chemistry: Strategies, Tools & Experiments, Shri Kala Prakashan (ISBN: 978-9385329456)
- Sidhwani, Tucker I; Sharma, R.K, (2020); An Introductory Text on Green Chemistry: For Undergraduate Students, Wiley (ISBN: 978-8126554072)
- Benyus, J.M. (2002); Biomimicry:Innovations Inspired by nature, HarperCollins. (ISBN: 9780060533229)
- Garay,A. L; Pichon, A.; James,S.L. "Solvent-free synthesis of metal complexes" Chem Soc Rev, 2007, 36,846-855.
- James H. Clark, Duncan Macquarrie (2002); Handbook of Green Chemistry and Technology, Wiley (ISBN: 9780632057153)

DISCIPLINE SPECIFIC ELECTIVE -12 (BIOMED-DSE-12) RESEARCH METHODOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Research Methodology BIOMED-DSE-12	4	3	-	1	XII Pass with Physics, Chemistry & biology	Basic knowledge of biology, mathematics and computers	Biomedical Science

Learning objectives

The Learning objectives of this course are as follows:

- The syllabus aims to educate students on the fundamentals of research methodology and familiarize them with the different search engines used in literature surveys.
- It will guide them in identifying research problems and developing research strategies to address them.
- The course will cover different approaches used in research, along with ethical considerations related to clinical research.
- In addition, students will learn about scientific writing and presentation skills.

Learning outcomes

Upon completion of this course, students will achieve the following learning outcomes:

- Develop the ability to identify a research problem, design and execute experiments, and analyze the resulting data.
- Comprehend and follow ethical guidelines for conducting research and accurately document research activities.
- Utilize various tools to write research papers and review articles effectively.
- Demonstrate effective presentation skills to communicate scientific work.

SYLLABUS OF BIOMED-DSE-12

Unit I: Introduction (6 hrs)

Basics of research methodology: Background of research area and generation of hypothesis, Types of Research: Experimental vs Theoretical; Descriptive vs Analytical; Fundamental vs Applied; Quantitative vs Qualitative.

Unit II: Literature Review (08 hrs)

Importance of literature review, common search engines such as NCBI, Google Scholar etc. used for literature surveys. Exploring various types of academic journals and publications fundamental to research: journals and e-books. Introduction to reference and citation management tools like Mendeley, Zotero and EndNote.

Unit III: Identifying a Research Problem and Designing of Experiment: (10 hrs)

Identification of a research problem (any one disease of national importance: tuberculosis/leprosy/diabetes/cardiovascular disease/neurodegenerative disorders), its national and international status. Experimental strategies: number and types of replicates and control, Statistical analysis of data using MS Excel/ R-Statistical tools.

Unit IV: Methods in Biomedical Research (08hrs)

Clinical Research and associated methodology, Epidemiology: Concepts and methods in the context of illustrative projects. Classical examples of epidemiological studies such as TB and leprosy, its challenges and limitations.

Unit V: Research Ethics and Intellectual Property (07hrs)

Understanding research ethics and its significance in scientific writing, Plagiarism, peer-review, conflict of interest, and research misconduct. Introduction to Intellectual Property Rights (IPR) such as Patent, Trademarks, Copyright, and Trade Secrets. Importance of IPR in research and innovation.

Unit VI: Research Presentation (06 hrs)

To write a research paper and review article. To prepare an oral and poster presentation of a research paper.Steps in writing a research grant proposal

Practical **(30 hrs)**

1. Literature survey on any one disease of national importance: tuberculosis/leprosy/diabetes/cardiovascular disease/neurodegenerative disorders
2. Creating bibliography in different formats using any available tools like Mendeley/ Zotero/ EndNote, etc.
3. Group exercise by students
    1. Writing a review article
    2. Writing a research report
    3. Powerpoint presentation
    4. Poster presentation

Essential Readings

- Walliman, N. (2017) Research Methods: The Basics, (2nd ed.), London; New York: Routledge; ISBN-10:1138693995
- Kumar, R. (2014) Research Methodology: A Step-by-Step Guide for Beginners (4th ed.), SAGE publisher; ISBN-10: 9789351501336
- The Craft of Research (Guides to writing, editing and publishing) (2008), Booth, W.C., Colomb, G.G., Williams, J.M., University of Chicago Press, 2008. (ISBN-13: 978-0226065663)

Suggestive Readings

- Research Methodology: A Step-by-Step Guide for Beginners (2010) 3rd ed., Kumar R., Pearson Education. (ISBN-13: 978-1849203012)
- Cresswell, J. (2009) Research Design: Qualitative and quantitative Approaches Thousand Oaks CA, (3rd ed.), Sage Publications
- Research in Education (2005) 10th ed., Best, J.W. and Kahn, J.V., Prentice Hall of India Pvt. Ltd. (ISBN-13: 978-0205458400)
- At the Bench: A Laboratory Navigator (2005) Barker, K., Cold Spring Harbor Laboratory Press (New York). ISBN: 978-087969708-2.
- Research Methodology - Methods and Techniques (2004) 2nd ed., Kothari C.R., New Age International Publishers. (ISBN-13 / EAN: 9788122415223)

DEPARTMENT OF ENVIRONMENTAL STUDIES

Category-I

SEMESTER - IV

BSC (H) ENVIRONMENTAL SCIENCE

DISCIPLINE SPECIFIC CORE COURSE – 10 (DSC-EVS-10): SYSTEMATICS AND BIOGEOGRAPHY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-EVS-10: SYSTEMATICS AND BIOGEOGRAPHY	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Gain insights into the principles and methods of systematic biology for determining evolutionary relationships among organisms
- Describe major biogeographic regions of the world and identify underlying factors responsible for their formation and evolution
- Familiarize with the different types of molecular and morphological characters used in systematic analysis
- Interpret phylogenetic trees constructed using molecular and morphological data in an evolutionary context
- Evaluate literature in systematics and biogeography and critically assess research questions and methods

Learning outcomes

After this course, students will be able to:

- Identify and classify different taxa using morphological and molecular characters
- Construct and interpret phylogenetic trees based on molecular and morphological data
- Analyze biogeographic patterns and use them to make inferences about evolutionary history

- Apply the principles and methods of systematics and biogeography to practical problems in conservation biology, ecology, and biotechnology
- Communicate effectively about the principles and methods of systematics and biogeography, and their applications to various areas of research and practice

SYLLABUS OF DSC-EVS-10

Theory (02 Credits: 30 lectures)

UNIT – I Concept, systematics approaches and taxonomic hierarchy (3 Week) (6 lectures)
Definition of systematics; taxonomic identification; keys; field inventory; herbarium; museum; botanical gardens; taxonomic literature; nomenclature; evidence from anatomy, palynology, ultrastructure, cytology, phyto-chemistry, numerical and molecular methods; taxonomy databases.

Concept of taxa (species, genus, family, order, class, phylum, kingdom); concept of species (taxonomic, typological, biological, evolutionary, phylogenetic); categories and taxonomic hierarchy

UNIT – II Nomenclature and systems of classification (2½ Week) (5 lectures)
Principles and rules (International Code of Botanical and Zoological Nomenclature); ranks and names; types and typification; author citation; valid publication; rejection of names; principle of priority and its limitations; names of hybrids; classification systems of Bentham and Hooker; Angiosperm Phylogeny Group (APG III) classification.

UNIT – III Numerical and molecular systematics (1½ Week) (3 lectures)
Characters; variations; Operational Taxonomic Units; character weighting and coding; phenograms; cladograms; DNA barcoding; phylogenetic tree (rooted, unrooted, ultrametric trees); clades: monophyly, paraphyly, polyphyly; homology and analogy; parallelism and convergence.

UNIT – IV Biogeography, Speciation and extinction (3½ Week) (7 lectures)
Genes as unit of evolutionary change; mutation; genetic drift; gene flow; natural selection; geographic and ecological variation; biogeographical rules – Gloger’s rule, Bergmann’s rule, Allen’s rule, Geist rule; biogeographical realms and their fauna; endemic, rare, exotic, and cosmopolitan species.

Types and processes of speciation – allopatric, parapatric, sympatric; ecological diversification; adaptive radiation, convergent and parallel evolution; dispersal and immigration; means of dispersal and barriers to dispersal; extinction.

UNIT – V Historical and ecological Biogeography (3½ Week) (7 lectures)
Earth’s history; paleo-records of diversity and diversification; continental drift and plate tectonics and their role in biogeographic patterns – past and present; biogeographical dynamics of climate change and Ice Age.

Species’ habitats; environment and niche concepts; biotic and abiotic determinants of communities; species-area relationships; concept of rarity and commonness; Island Biogeography theory; Equilibrium Theory of Insular Biogeography; geography of diversification and invasion; phylogeography.

UNIT – VI Conservation Biogeography (1 Week) (2 lectures)

Application of biogeographical rules in design of protected area and biosphere reserves; use of remote sensing in conservational planning.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Construct and compare phylogenetic trees based on morphological and molecular data
2. Extract and quantify DNA from various organisms
3. Conduct PCR and amplify a specific gene using a target primer
4. Identify different taxa using morphological and molecular characters
5. Construct, analyze and infer phylogenetic trees based on molecular data by using software like PAUP*, RAxML, and MrBayes
6. Use and construct a phylogenetic tree based on morphological characters
7. Molecular Characters: Students should learn how to use molecular characters to construct a phylogenetic tree
8. Compare and contrast the anatomy of different organisms to understand their evolutionary relationships
9. Map and identify the distribution of organisms across the world and the factors that influence their distribution
10. Analyze the factors explaining biogeographic patterns of distribution of a target species using hypothesis of vicariance and dispersal
11. Estimate the timing of evolutionary events based on molecular clocks
12. Identify and analyze different biogeographic regions of the world and the unique flora and fauna found in each
13. Estimate divergence times between different lineages using molecular data

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Essential/recommended readings

- Baum, D. A., & Smith, S. C. (2013). Systematic Biology. John Wiley & Sons.
- Briggs, C. J. (2016). Biogeography: An ecological and evolutionary approach. Wiley-Blackwell.
- Cox, L. R., & Moore, P. D. (2010). Biogeography: An introduction to the study of plants and animals in time and space. Wiley-Blackwell.
- Heads, M. (2019). Biogeography and evolution. New Zealand. CRC Press.
- Lieberman, B. S., & Garland, R. L. (2020). Phylogenetic trees made easy: A how-to manual. Sinauer Associates.
- Lomolino, I., Riddle, B. R., & Whittaker, R. J. (2016). Biogeography: Principles and Practice. Sinauer Associates.

- Pressey, R. L., Anderson, M. B., & Groves, R. G. (2019). Systematic conservation planning. Oxford University Press.
- Wiley, E. H., & Lieberman, B. S. (2011). Systematics and evolution: Theory and practice. Wiley-Blackwell.

Suggestive readings

- Antonelli, A. (2019). Historical biogeography: An introduction. Princeton University Press.
- Dayrat, B. H. E. W. (2005). Phylogenetic systematics. University of Kansas Press.
- Guglielmino, A. G., & Barbujani, A. V. (2017). Biogeography: A natural science of human diversity. Cambridge University Press.
- Hennig, P. (1966). Systematics: A course of lectures. Columbia University Press.
- Nei, M., & Kumar, S. (2020). Molecular evolution and phylogenetics. Oxford University Press.
- Revell, L. V. (2020). Phylogenetic comparative methods: A guide for ecologists. Princeton University Press.
- Wiley, E. O. (2020). Phylogenetics: Theory and practice of phylogenetic systematics. John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 11 (DSC-EVS-11): ENVIRONMENTAL TOXICOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-EVS-11: ENVIRONMENTAL TOXICOLOGY	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Analyze sources, fate, and effects of toxic substances in the environment
- Train in methods relevant to assess and manage environmental risks associated with toxic substances
- Investigate the impact of environmental toxicants on wildlife and ecosystems, including the effects on reproductive success and population dynamics.
- Examine management practices related to the use, disposal, and treatment of hazardous substances and wastes.
- Compare scientific methods and techniques to measure and monitor environmental toxicants in different environmental media.
- Familiarize with emerging issues and technologies in environmental toxicology
- Promote critical thinking and problem-solving skills through case studies and hands-on activities related to environmental toxicology.

Learning outcomes

After this course, students will be able to

- Define and describe the scope and historical background of environmental toxicology.
- Identify, classify, and predict fate and transport of different types of toxic substances in the environment
- Evaluate the risks associated with toxic substances and apply risk assessment and management strategies
- Analyze the effects of toxic substances on wildlife and ecosystems, and propose solutions to mitigate their impacts.
- Compare and contrast the toxicity of different pollutants and their possible mechanisms of action.
- Apply their knowledge of environmental toxicology to current environmental issues and develop potential solutions.

SYLLABUS OF DSC-EVS-11

Theory (02 Credits: 30 lectures)

UNIT – I Introduction to Environmental Toxicology (1 Week) (2 lectures)
Definition, Historical perspective, Types of Toxic substances: types, properties, sources, and fate and transport, biomagnification and bioaccumulation.

UNIT –II Toxicology of Air and Water (2 Weeks) (4 lectures)
Toxic air contaminants, Health effects of air pollution, Acid rain and its impacts, Ozone depletion and its impacts, Water pollution and its sources, Health effects of water pollution, Eutrophication and hypoxia in aquatic ecosystems, Marine pollution and its impacts, Emerging issues in air and water toxicology

UNIT –III Toxicology of Soil and Hazardous Waste (3½ Weeks) (7 lectures)
Sources and types of hazardous waste, Health effects of soil contamination: from heavy metals, metalloids, and organic contaminants; Brownfields and urban redevelopment, Superfund sites and environmental justice, Pesticide and Pharmaceuticals: classification, history of use, distribution in environment, fate and transport, health effects, and ecotoxicology; Emerging issues in environmental toxicology by hazardous waste, pesticides and pharmaceuticals

UNIT –IV Toxicology of Radiation and Nanoparticles (3 Weeks) (6 lectures)
Ionizing and non-ionizing radiation, Health effects of radiation, Radioactive waste and nuclear accidents, Nanoparticles: properties, behavior in the environment, fate and transport, health effects, and ecotoxicology; Emerging issues in radiation and nanoparticle toxicology, Risk assessment and risk management of radiation and nanoparticles

UNIT –V Emerging Issues in Environmental Toxicology (2½ Weeks) (5 lectures)
Endocrine disruption and its impacts, Climate change and toxicology, Emerging contaminants (e.g., microplastics, PFAS), Global perspectives, Ethics in environmental toxicology, Careers in environmental toxicology, Future directions in environmental toxicology research

UNIT –VI Management and regulation of environmental toxicants (1½ Weeks) (3 lectures)
Environmental regulations and policy, Hazardous waste regulations and management, Pesticide and pharmaceutical use and regulation, Ecotoxicology and wildlife toxicology, Risk assessment and risk management, Remediation and restoration of contaminated sites

UNIT –VII Environmental forensics (1½ Weeks) (3 lectures)
Definition, Applications in environmental toxicology, Common techniques (e.g., isotope analysis, DNA fingerprinting), Case studies in identifying sources of contamination, Future developments and potential applications in environmental sustainability.

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Analyze effects of pH on the toxicity of heavy metals on model organism, such as Daphnia

2-3. Determine toxicity of varying concentration of industrial effluent on common alga and measure its growth and survival rates

4-5. Effects of heavy metal toxicity on plant growth, focussing on different plant parts and physiological characteristics

6. Analyze effects of climate change on the abundance and diversity of pollinators under different climatic conditions
7. Analyze the abundance and diversity of nematodes (e.g., Caenorhabditis elegans) in the background of use of environmental chemicals
8. Effects of herbicides on the abundance and diversity of weed populations in response to the use of different herbicides
9. Test the effects of a target organic contaminant on behaviour and mortality of earthworm

10-11. Measure developmental abnormalities in zebrafish embryos due to toxicity of target environmental chemicals

12-13. Prepare and characterize nanoparticles of selected heavy metal and assess effect of nanoparticles on plant growth

14. Effects of various concentrations of road salt on freshwater organisms (e.g., zooplankton) and measure changes in their behavior and survival

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Crosby, D. G. (2019). Environmental toxicology and chemistry (3rd ed.). CRC Press.
- Landis, W. G., Sofield, R. M., & Yu, M.-H. (2019). Introduction to environmental toxicology (4th ed.). CRC Press.
- Lehrer, I., & Poole, J. B. (2019). Principles of environmental toxicology (4th ed.). CRC Press.
- Newman, M. C., Roberts, M. H., Hale, R. C., & Robinson, E. M. (Eds.). (2020).

Environmental Toxicology: Biological and Health Effects of Pollutants (4th ed.). CRC Press.
- Yu, M.-H., & Yan, G. W. S. (2020). Environmental toxicology: Biological and health effects of pollutants (3rd ed.). CRC Press.

Suggestive readings

- Ballantyne, B., Marrs, T. C., & Syversen, T. (2020). Toxicology: The basic science of poisons (4th ed.). CRC Press.
- Kamrin, M. A. (2020). Introduction to Environmental Toxicology: Molecular Substructures to Ecological Landscapes (5th ed.). CRC Press.
- Meyers, R. A. (Ed.). (2018). Environmental toxicology: Selected entries from the Encyclopedia of Sustainability Science and Technology. Springer
- Smart, R. C., & Hodgson, E. (2018). Molecular and biochemical toxicology (5th ed.). John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 12 (DSC-EVS-12): RESTORATION ECOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-EVS-12: RESTORATION ECOLOGY	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Gain insights into principles and concepts of restoration ecology to understand various approaches and techniques used in ecological restoration
- Provide hands-on experience with ecological restoration techniques and field methods
- Promote critical thinking and problem-solving skills in the context of ecological restoration for innovation related methods
- Investigate the interdisciplinary issues and practices linked with ecological restoration

Learning outcomes

After this course, students will be able to

- Describe the ecological, economic and social factors that lead to ecosystem degradation
- Evaluate and select appropriate ecological restoration techniques for different types of ecosystems
- Design ecological restoration projects and identify appropriate methods to monitor and evaluate the restoration practices
- Undertake collaborative programmes to understand and solve ecological restoration problems
- Critically evaluate the scientific and technical aspects of ecological restoration research and practice.

SYLLABUS OF DSC-EVS-12

Theory (02 Credits: 30 lectures)

UNIT – I Fundamentals of Restoration Ecology (3½ Weeks) (7 lectures)

Definition and history of restoration ecology, Principles of restoration ecology, Restoration process: planning, implementation, and monitoring; Ecosystem services and the importance of restoration ecology; Challenges and limitations of restoration ecology; Case studies in restoration ecology; Ethics and values in restoration ecology; Restoration ecology and environmental policy

UNIT – II Ecological Foundations for Restoration Ecology: (3 Weeks) (6 lectures)

Role of ecological concepts in restoration ecology: ecological succession. Biodiversity, ecological interactions, and habitat fragmentation and ecosystems; Climate change and its impact on restoration ecology, Invasive species and their role in ecosystem degradation and restoration, Ecological thresholds, and their relevance to restoration ecology

UNIT – III Techniques and Tools for Restoration Ecology (3 Weeks) (6 lectures)

Ecological site assessment and inventory, Restoration planning and design, Techniques for soil and water conservation in restoration ecology, Seed collection, propagation, and planting techniques for restoration, Wildlife management in restoration ecology, Restoring aquatic ecosystems: techniques and challenges, Biomimicry and ecological engineering in restoration ecology. Evaluating and monitoring restoration outcomes

UNIT – IV Ecosystem Restoration (2 Weeks) (4 lectures)

Restoration of: grasslands, forests, wetlands, agricultural and urban landscapes, mining and industrial sites; Restoration of ecosystem services in aquatic ecosystems

UNIT – V Synthesis and Applications of Restoration Ecology (3½ Weeks) (7 lectures)

Integrating restoration ecology with conservation biology, Adaptive management in restoration ecology, Restoring ecosystem services and human well-being, Restoring cultural and spiritual values in ecosystems, Restoring resilience and resistance in ecosystems, Restoring ecosystem connectivity and migration corridors, Restoring biodiversity in the face of global change, and The future of restoration ecology and its role in sustainability

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Field visits to assess the magnitude of degradation in selected ecosystems
2. Analyse the success of ecosystem restoration case studies in Delhi and identify the underlying principles
3. Assess the current status of a degraded ecosystem and identify potential areas for restoration
4. Learn techniques for collecting and propagating native plant species for use in restoration projects

5-6. Design methods for reducing erosion and managing nutrient runoff in restored ecosystems
7-8. Examine techniques for planting and establishing native plant species in a restored ecosystem
9-10. Evaluate methods for assessing and managing wildlife habitat in a restored ecosystem
10-11. Assess efficacy of different methods for monitoring and evaluating restoration outcomes in a restored ecosystem
12. Learn techniques for managing invasive species in a restored ecosystem
13-14. Design and implement a restoration plan for selected degraded ecosystems (terrestrial and aquatic) to improve the quality of habitat

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Clewell, A. F., & Aronson, J. (Eds.). (2013). Ecological restoration: Principles, values, and structure of an emerging profession (2nd ed.). Island Press.
- Erickson, A. L., Ryan, C. M., & Jones, T. A. (Eds.). (2021). The science of ecological restoration: Creating resilience in a changing world. Island Press.
- Hobbs, R. J., & Suding, K. N. (2018). New models for ecosystem dynamics and restoration. CRC Press.
- Palmer, M. A. (2016). Restoration: The science of restoring ecosystems and the human spirit. Island Press.
- Temperton, V. M., Hobbs, R. J., Nuttle, T., Halle, S., & Tonev, C. (Eds.). (2020). Novel ecosystems: Intervening in the new ecological world order. John Wiley & Sons.
- Yaffee, S. L., & Wondolleck, J. M. (2019). Ecosystem management in the United States: An assessment of current experience. Routledge.

Suggestive readings

- Allison, S. D., & Murphy, S. D. (Eds.). (2019). Ecosystem collapse and restoration. Oxford University Press.
- Benedetti-Cecchi, L. (2021). Marine restoration ecology. Oxford University Press.
- Benson, M. H., & Phillips, A. (Eds.). (2016). Ecosystem services and conservation in urbanizing Asia. Springer.
- Higgs, E. S., Falk, D. A., Guerrini, A., Hall, M. P., & Harris, J. G. (Eds.). (2021). The Routledge handbook of ecological and environmental restoration. Routledge.
- Moreno-Mateos, D., & Perring, M. P. (Eds.). (2019). Ecological restoration and environmental change: Renewing damaged ecosystems in a changing world. Routledge.
- Palmer, M. A., Zedler, J. B., & Falk, D. A. (Eds.). (2021). Foundations of restoration ecology (2nd ed.). Island Press.

- Suding, K. N., & Hobbs, R. J. (Eds.). (2019). Handbook of restoration ecology (2nd ed.). Oxford University Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE (DSE-EVS-10): ECOSYSTEM MONITORING

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
DSE-EVS-10: ECOSYSTEM MONITORING	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Introduce principles and practices of monitoring ecological systems for designing and implement monitoring programmes
- Provide knowledge of the importance of monitoring for conservation and management of natural resources.
- Impart skills in data analysis and interpretation and provide with hands-on experience in monitoring programmes
- Encourage to communicate the results of monitoring programs effectively and promote ethical principles in monitoring

Learning outcomes

After the course, the students will be able to

- Explain the principles of ecosystem monitoring and design and implement monitoring programmes
- Analyze and interpret data from monitoring programmes and identify specific monitoring methods for conservation and management of natural resources
- Conduct monitoring programmes and communicate the results effectively
- Apply ethical and scientific principles in monitoring programmes

SYLLABUS OF DSE-EVS-10

Theory (02 Credits: 30 lectures)

UNIT – I Introduction to Ecosystem Monitoring (2½ Weeks) (05 lectures)

Introduction to ecosystem monitoring, Principles of ecosystem monitoring, Importance of monitoring for conservation and management, Types of monitoring programmes, Steps in designing a monitoring programme, Sampling methods, Data analysis and interpretation, Communication of monitoring results, Ethics in monitoring, Case studies in ecosystem monitoring

UNIT – II Ecological Indicators (3 Weeks) (06 lectures)

Definition and types of ecological indicators, Commonly used ecological indicators in different ecosystems (e.g., terrestrial, aquatic, marine), Measurement techniques for ecological indicators (e.g., field sampling, remote sensing, citizen science), Interpretation of ecological indicators and their relationship to ecosystem health and function, Applications of ecological indicators in environmental management and policy

UNIT – III Sampling Techniques (4 Weeks) (08 lectures)

Different types of sampling techniques and their advantages and limitations, Sampling design and planning for ecosystem monitoring (e.g., sample size, spatial and temporal scales), Sampling protocols and techniques for climate and different types of ecosystem components, (e.g., soil, water, air, biota), Quality assurance and quality control in ecosystem monitoring sampling, Data management and analysis considerations for sampling data

UNIT – IV Data Analysis and Visualization (3½ Weeks) (07 lectures)

Types of data collected in ecosystem monitoring (e.g., continuous, discrete, categorical), Statistical techniques and software for analyzing ecosystem monitoring data (e.g., regression analysis, multivariate analysis, machine learning), Data visualization techniques for ecosystem monitoring data (e.g., charts, graphs, maps), Communicating monitoring results to stakeholders (e.g., reports, presentations, online platforms), Ethical considerations in the analysis and visualization of ecosystem monitoring data

UNIT – V Ecosystem Monitoring in Practice (2 Weeks) (04 lectures)

Overview of a specific ecosystem monitoring program (e.g., the National Ecological Observatory Network, Long-Term Ecological Research sites), Planning and design of an ecosystem monitoring project, Analysis of a case study of ecosystem monitoring with respect to different practices mentioned in other units, Reflection on the challenges and opportunities of implementing ecosystem monitoring programs in practice.

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Measure plant diversity using different methods to assess species richness, diversity indices, and community structure
2. Survey nearby ecosystem to identify and monitor invasive species and its possible impact
3. Analyze remote sensing data for ecosystem monitoring, including satellite imagery and aerial photographs
4. Learn different soil sampling methods and monitor soil properties
5. Measure potential carbon sequestration by trees of a nearby area
6. Analyze climate data, including temperature, precipitation, and atmospheric carbon dioxide concentrations
7. Hands-on experience in testing water quality parameters such as pH, dissolved oxygen, and nutrients using rapid methods
8. Conduct bird surveys and identify common bird species of nearby ecosystem
9. Hands-on experience in setting up and monitoring wildlife camera traps, and identifying common wildlife species
10. Design and conduct social surveys to understand public perceptions, attitudes, and behaviors related to ecosystem (wetland, etc.) monitoring
11. Record and monitor leaf-out, flowering, and fruiting of selected species of nearby ecosystem
12. Survey amphibians in ecosystems by method of your choice including visual surveys or call surveys or capture-mark-recapture
13. Sample and identify insects in a nearby area, including sweep netting or pitfall traps or light traps
14. Engage citizen scientists in ecosystem monitoring programme, including data collection, quality assurance, and community engagement

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Bartram, J., & Ballance, R. (2017). Water Quality Monitoring: A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programs. CRC Press.
- Becker, C. G., Bastos, R. P., & Silvano, D. L. (2021). Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Smithsonian Institution Press
- Burden, F. R., & Pitt, R. F. (2013). Environmental Monitoring Handbook. McGraw Hill.
- Lindenmayer, D., Gibbons, P., & Bennett, A. (2019). Monitoring ecosystems: Interdisciplinary approaches for evaluating ecoregional initiatives. CSIRO Publishing
- Stenseth, N. C., & Furevik, T. (2016). Principles and Methods of Ecosystem-based Management. CRC Press.

Suggestive readings

- Aronson, J. (2017). The Practice of Ecosystem Services Evaluation: An Introduction. Springer.
- Ferretti, M., & Fischer, R. (2013). Forest Monitoring: Methods for Terrestrial Investigations in Europe with an Overview of North America and Asia. Elsevier.
- Kobayashi, T., Yang, W., & Qi, Y. (2020). Remote sensing of ecosystem health with prism and modis data. CRC Press.
- Krkosek, M., & Bateman, A. (2019). Wildlife Population Monitoring: Some Practical Considerations. Oxford University Press.
- Rees, Y., Brazeau, M., & Santos, L. F. (2021). Environmental monitoring using UAVs. Springer.
- Schulin, R., & Kutílek, M. (2017). Soil Monitoring: Early Detection and Surveying of Soil Contamination and Degradation. Springer.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-EVS-11): ENVIRONMENTAL INDICATORS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
DSE-EVS-11: ENVIRONMENTAL INDICATORS	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Understand the concept of environmental indicators and their role in measuring and assessing environmental quality
- Learn how to select, analyze, and interpret various types of environmental indicators to evaluate the condition of natural resources and ecosystems
- Develop an understanding of select and use environmental indicators in environmental policy and decision-making
- Learn about the practical applications of environmental indicators in different sectors such as government, business, and non-governmental organizations.
- Gain an appreciation of the interdisciplinary nature of environmental indicators, and the importance of collaboration among different disciplines to address environmental issues

Learning outcomes

After successful completion of this course, students will be able to:

- Define, describe and identify environmental indicators to measure and assess environmental quality
- Select appropriate environmental indicators based on specific environmental issues, and apply appropriate methods for data collection and analysis
- Evaluate the effectiveness of different environmental indicators and their relevance to environmental policy and decision-making.
- Communicate environmental indicator data effectively to different audiences using appropriate formats and techniques.
- Apply knowledge and skills in business, society, policy formulation and implementation, to address environmental issues

SYLLABUS OF DSE-EVS-11

Theory (02 Credits: 30 lectures)

UNIT – I Introduction to Environmental Indicators (2 Weeks) (4 lectures)
Environmental Indicators: overview, types, relevance in environmental sustainability, environmental health and social justice, Principles of Environmental Indicator Selection, Environmental Monitoring and Data Collection. Environmental Indicator Reporting and Communication

UNIT – II Air Quality Indicators (2 Weeks) (4 lectures)
Air Pollution Sources and Emissions, Criteria Air Pollutants and their Health Effects, Ozone Depletion and Stratospheric Ozone Protection, Indoor Air Quality and Health; Air Quality: standards, guidelines, monitoring, sampling, management strategies, policies, trends and projections, Quality parameters: particulate matter, ozone, nitrogen oxides, sulfur dioxide, carbon monoxide, volatile organic compounds, lead, radon, and carbon dioxide
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UNIT – III Water Quality Indicators (2½ Weeks) (5 lectures)
Water Pollution Sources and Pathways, Surface Water and Groundwater Quality Indicators, Drinking Water Quality and Treatment, Water Pollution Control Strategies and Policies, Non-Point Source Pollution and Best Management Practices, Water Quality: standards, guidelines, monitoring, sampling, trends and projections; Quality parameters: dissolved oxygen, pH, temperature, turbidity, nutrient concentrations, chlorophyll-a, biological oxygen demand, fecal coliform bacteria, total dissolved solids, and toxic substances

UNIT – IV Biodiversity Indicators (2½ Weeks) (5 lectures)
Biodiversity: concepts, definitions, components, levels, measurement, assessment, threats, conservation strategies and policies, trends and projections; Ecosystem Services and Biodiversity, Biodiversity and Climate Change, Parameters: species richness and diversity, genetic diversity, endemic species, threatened species, habitat extent, fragmentation and quality, ecosystem services

UNIT – V Land Use and Soil Indicators (3½ Weeks) (7 lectures)
Land Use and Land Cover Change, Urbanization and Suburbanization Trends, Productivity of Agricultural and Forests, Wilderness Management, Mining and Mineral Extraction Impacts, Land Use and Ecosystem Services, Land Use Planning and Policy, Land Use Change and Climate Change; Soil health: soil organic matter, texture, pH, nutrients, biodiversity and microbial activity, respiration aggregate stability, compaction, and water holding capacity

UNIT – VI Climate Change Indicators (2½ Weeks) (5 lectures)
Greenhouse Gas Emissions and Sinks, Climate Change: science, impacts mitigation strategies and policies, adaptation strategies and policies, vulnerability and risk assessment; Climate Change Indicators: for terrestrial and aquatic ecosystems, for human health and societal well-being (average global temperature, sea-level rise, ocean acidification, carbon dioxide concentrations, extreme weather events, arctic sea ice and glaciers and ice sheets,

ecosystem productivity and species phenology, heat-related and mediated illnesses, total energy consumption); and Climate Change and Global Environmental Governance

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Investigate variations in different surfaces to absorb and reflect heat
2. Determine pattern of sea-level rise at selected coastal location over time and propose its causes and potential impacts
3. Investigate the sources and concentrations of carbon dioxide in different indoor and outdoor environments and explore ways to reduce carbon dioxide emissions
4. Collect and analyze data on weather patterns and events over time and investigate the impacts of extreme weather events on human communities and ecosystems
5. Monitor changes in Arctic sea ice extent and thickness over time and investigate the impacts of sea ice loss on Arctic ecosystems and global climate
6. Conduct field surveys to measure plant and animal diversity and abundance in different habitats and investigate the impacts of habitat loss and fragmentation on biodiversity
7. Analyze air and water quality data in different urban and rural environments and investigate the links between environmental pollution and human health outcomes
8. Monitor energy consumption and greenhouse gas emissions in different households, buildings, and industries and investigate strategies for reducing energy use and transitioning to renewable energy sources
9. Compare different land use change for variations in soil health and fertility
10. Analyze the impact of land use on health of selected water bodies
11. Conduct surveys to identify the links between environmental exposure of noise or air pollution and onset of stress and anxiety in humans
12. Monitor glacier and thickness of ice sheet using GIS and identify the changes in glacier and water resources and rise in sea level
13. Analyze the relationship between economic growth and environmental impacts using temporal data from economics and environment and suggest ways to promote sustainable development
14. Use the case study method to analyze companies having prioritized environmental and social concerns in their business practices and their impacts on society, environment, and economy

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available

data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Hák, T., Moldan, B., & Dahl, A. L. (2020). Sustainability indicators: A scientific assessment. Springer.
- Mulder, K. F. (2018). Environmental sustainability indicators: An introduction. Routledge.
- Murgante, B., Misra, S., Carullo, A., & Torre, C. M. (Eds.). (2019). Environmental sustainability indicators for industry: Methods and tools. Springer.
- Saad-Sulonen, J., & Horelli, L. (2020). Urban environmental indicators: Tools for liveability and sustainability. Routledge.
- Sala, S., & Farioli, F. (2020). Environmental Indicators: Tools for Evaluation and Decision Making in Resource Management. Springer.

Suggestive readings

- Brouwer, R., & van Ek, R. (Eds.). (2021). Environmental and Resource Valuation with Revealed Preferences: Approaches and Methods. Routledge.
- Campbell, L. M., Gray, N. J., & Fairbanks, L. W. (Eds.). (2021). The Routledge Handbook of Environmental Governance and Sustainability. Routledge.
- Farinha-Marques, P., & Pina, A. (2019). Green supply chain management: Environmental sustainability indicators. Springer.
- Singh, R. B., & Mallick, J. (2019). Eco-friendly and sustainable agriculture: Environmental sustainability indicators. Springer.
- Tukker, A., & Dietz, F. (Eds.). (2020). Environmental Indicator Frameworks for Policy: A Comparative Analysis of Approaches in Europe. Routledge.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE (DSE-EVS-12): ECOSYSTEM STEWARDSHIP

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
DSE-EVS-12: ECOSYSTEM STEWARDSHIP	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Introduce the principles and practices of ecosystem stewardship for valuing ecosystems from the perspective of ecology, society, and economy
- Explore the challenges and opportunities of managing ecosystems in a changing world.
- Provide hands-on experience in ecosystem management through practical exercises and case studies
- Foster communication and collaboration skills for engaging with stakeholders in ecosystem stewardship

Learning outcomes

After the course, students will be able to:

- Demonstrate an understanding of the key principles and practices of Ecosystem Stewardship
- Identify and describe the ecological, social, and economic values of ecosystems
- Apply practical tools and techniques for ecosystem management, including stakeholder engagement, biodiversity assessment, and habitat restoration
- Analyze and interpret data on ecosystem health and identify strategies for ecosystem restoration and conservation
- Develop effective communication and collaboration skills for engaging with stakeholders in ecosystem stewardship

SYLLABUS OF DSE-EVS-12

Theory (02 Credits: 30 lectures)

UNIT – I Introduction to Ecosystem Stewardship (2½ Weeks) (5 lectures)
Concept of Ecosystem Stewardship, Ecological Principles of Ecosystem Stewardship, Historical and Contemporary Perspectives, Role of stewardship in conservation, Ethics and Values in Ecosystem Stewardship, Importance of Ecosystem Services, Ecosystem Resilience and Sustainability, Ecosystem Restoration and Rehabilitation

UNIT – I Ecosystem Management (2 Weeks) (4 lectures)
Principles of Ecosystem Management, Ecosystem Management Planning and Implementation, Multiple Use Management, Ecosystem-Based Management, Adaptive Management, Stakeholder Engagement and Collaboration, Legal and Institutional Frameworks for Ecosystem Management, Economic Valuation of Ecosystem Services

UNIT – I Ecosystem Restoration (2 Weeks) (4 lectures)
Principles of Ecosystem Restoration, Restoration Planning and Implementation, Ecological Succession and Restoration, Restoration Techniques and Strategies, Restoration of Degraded Landscapes, Restoring Biodiversity and Ecosystem Functioning, Community-Based Restoration, Monitoring and Evaluation of Ecosystem Restoration

UNIT – IV Biodiversity Conservation and Ecosystem Services (3 Weeks) (6 lectures)
Biodiversity: importance of conservation, threats, link with ecosystem services; Conservation Planning and Implementation, Protected Areas and their Management, Habitat Restoration and Management, Wildlife Conservation, Invasive Species Management, Community-Based Conservation, Ecosystem Services: types, economic valuation, ecological and social drivers; Trade-offs and Synergies in Ecosystem Services, Payments for Ecosystem Services, Green Infrastructure and Ecosystem Services, Case studies of Ecosystem Services

UNIT – V Human Dimensions of Ecosystem Stewardship (2½ Weeks) (5 lectures)
Human-nature relationship and its impact on Ecosystems, Social-Ecological Systems and their Resilience, Indigenous and Local Knowledge Systems, Community-Based Management and Decision Making, Conflict Management and Resolution, Environmental Justice, Public Participation and Environmental Governance, Cultural Diversity and Ecosystem Stewardship

UNIT – VI Emerging Issues in Ecosystem Stewardship (3 Weeks) (6 lectures)
Influence of Climate Change on: natural ecosystems, agriculture, and urban ecosystems; Integrated watershed management, energy and natural resources, Linking technology with ecosystem stewardship, Ecosystem-based disaster risk reduction, Policy and legal frameworks, Stakeholder participation, Decentralized governance and community-based management, Future directions in ecosystem stewardship.

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Conduct a baseline assessment of a local ecosystem, including identifying key ecological features, ecosystem services, and human impacts
2. Develop a management plan for a local ecosystem, including setting objectives, identifying management actions, and monitoring progress
3. Conduct a stakeholder analysis for an ecosystem management project, including identifying stakeholders, assessing their interests and needs, and developing strategies for engagement
4. Identify and map habitats in a local ecosystem, including key species and their ecological roles
5. Develop a restoration plan for a degraded ecosystem, including identifying restoration objectives, selecting appropriate restoration techniques, and monitoring progress
6. Assess the economic value of ecosystem services in a local ecosystem, including identifying beneficiaries, estimating the economic value of services, and developing strategies for payment
7. Carry out a social impact assessment of an ecosystem management project, including identifying and assessing potential social impacts, and developing strategies for mitigating negative impacts and enhancing positive impacts
8. Develop a community-based ecosystem management project, including identifying and engaging stakeholders, developing a collaborative management plan, and evaluating project outcomes
9. Develop a climate adaptation plan for a local ecosystem, including identifying vulnerable species and ecosystems, developing adaptation strategies, and monitoring progress
10. Evolve a payment for ecosystem services (PES) project for a local ecosystem, including identifying beneficiaries, estimating the economic value of services, and developing a PES scheme
11. Conduct an ecosystem-based disaster risk reduction project, including identifying vulnerable ecosystems, developing strategies for risk reduction, and monitoring progress
12. Develop a water resources management project within your institute or residential area, including identifying and addressing water scarcity, improving water quality, and developing water governance mechanisms
13. Plan an urban ecosystem management project, including identifying green infrastructure, improving air quality, and enhancing biodiversity in urban areas

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Baggio, J. A., Barnett, A. J., Perez-Ibarra, I., & Rubiños, C. (Eds.). (2021). Governance for ecosystem stewardship: An institutional perspective. Routledge.
- Chapin III, F. S., Carpenter, S. R., Kofinas, G. P., Folke, C., Abel, N., & Clark, W. C. (2010). Ecosystem stewardship: sustainability strategies for a rapidly changing planet. Springer.
- Hobbs, R. J., Higgs, E. S., & Hall, C. M. (Eds.). (2019). Ecosystem stewardship: Principles and practices for sustainability and resilience. CRC Press.
- Kareiva, P., & Marvier, M. (2012). Conservation science: Balancing the needs of people and nature. Roberts & Company.
- Peterson, G. D., & Cumming, G. S. (2013). Scenario planning: a tool for conservation in an uncertain world. The University of Chicago Press.

Suggestive readings

- Berkes, F. (2017). Sacred ecology. Routledge.
- Brown, K., & Westaway, E. (2011). Agency, capacity, and resilience to environmental change: Lessons from human development, well-being, and disasters. Routledge.
- Côté, I. M., & Darling, E. S. (2021). Conservation in the Anthropocene ocean. Oxford University Press.
- Kareiva, P., & Marvier, M. (2020). Conservation science: Balancing the needs of people and nature. Roberts & Company.
- Peterson, G. D., Cumming, G. S., & Carpenter, S. R. (Eds.). (2021). Scenario planning for conservation and management. Springer.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE (DSE-EVS-13): GREEN URBANIZATION

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
DSE-EVS-13: GREEN URBANIZATION	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Develop an understanding of the principles, concepts, challenges and opportunities of green urbanization and sustainable urban development
- Impart skills in designing sustainable urban development strategies that promote environmental, social, and economic sustainability
- Empower with evaluating the effectiveness of sustainable urban development strategies.
- Provide insights into the role of urban planning and policy in promoting green urbanization and sustainable urban development
- Gain importance of social equity and community engagement in green urbanization and sustainable urban development

Learning outcomes:

After the course, students will be able to

- Describe the principles and concepts of green urbanization and its linkages with sustainable development
- Design sustainable urban development strategies that promote environmental, social, and economic sustainability
- Evaluate and explain the effectiveness of sustainable urban development strategies and the role of urban planning and policy in promoting green urbanization
- Explain the importance of interdisciplinary and collaborative approaches to green urbanization and sustainable urban development
- Communicate and collaborate effectively with stakeholders in green urbanization and sustainable urban development projects

SYLLABUS OF DSE-EVS-13

Theory (02 Credits: 30 lectures)

UNIT – I Introduction to Green Urbanization and Sustainable Urban Design (3½ Weeks) (7 lectures)

What is Green Urbanization?, Concept of sustainability in urbanization, Historical context and evolution of urbanization, Challenges and opportunities of Green Urbanization, Role of urban planning in promoting Green Urbanization

Principles of sustainable urban design, Importance of green spaces in urban areas, Role of urban design in promoting sustainable transportation, Importance of green infrastructure in urban areas, Urban heat island mitigation strategies

UNIT – II Sustainable Transportation (2 Weeks) (4 lectures)

Sustainable transportation planning and policy, Public transportation systems and infrastructure, Active transportation options and infrastructure (walking, biking), Electric vehicles and charging infrastructure, Transit-oriented development (TOD) and its benefits

UNIT – III Green Buildings and Energy Efficiency (2 Weeks) (4 lectures)

Principles of green building design, Energy-efficient building design and technologies, Role of building codes and standards in promoting green building, Renewable energy systems for urban areas, Green building certification programs and their benefits

UNIT – IV Sustainable Water Management (2 Weeks) (4 lectures)

Importance of sustainable water management in urban areas, Water conservation and efficiency strategies, Sustainable stormwater management, Water reuse and recycling strategies, Green infrastructure for stormwater management

UNIT –V Sustainable Waste Management (2 Weeks) (4 lectures)

Importance of sustainable waste management in urban areas, Strategies for reducing waste and increasing recycling, Composting and organic waste management, Waste-to-energy technologies and their benefits, Extended Producer Responsibility (EPR) and its role in sustainable waste management

UNIT –VI Social Equity and Financing Green Urbanization (3½ Weeks) (7 lectures)

Social equity-environmental justice-green urbanization, Community for sustainable urban planning, Strategies for affordable housing and sustainable development, Green spaces for all

Public-private partnerships for sustainable urban development, Green bonds and sustainable urban projects, Tax incentives for green urbanization, Green banks and financing for urban sustainability, Crowdfunding and for financing urban sustainability

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Conduct a case study on a green urban development project and evaluate its effectiveness in promoting sustainability
2. Design a green infrastructure plan for a specific urban area, considering factors such as land use, vegetation, and water management
3. Develop a sustainable transportation plan for an urban area, incorporating options such as public transit, cycling, and walking
4. Conduct a building energy audit and recommend strategies for reducing energy consumption and increasing efficiency
5. Develop a green building certification programme and evaluate its potential benefits for promoting sustainable urban development.
6. Design a stormwater management plan for an urban area, incorporating green infrastructure and water reuse strategies
7. Conduct a waste audit and recommend strategies for reducing waste and increasing recycling in an urban area
8. Develop a green space plan for an urban area, considering factors such as biodiversity, recreation, and community engagement
9. Design a sustainable urban food system plan, considering factors such as local food production, distribution, and waste reduction
10. Conduct a social equity assessment of a green urban development project and recommend strategies for promoting equitable outcomes
11. Survey of public perceptions of green urbanization and evaluate the potential for public support
12. Develop a public outreach campaign to promote green urbanization and sustainability
13. Analyze the potential for green jobs and economic development in the green urbanization sector

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Abbott, C. (2021). Greening cities in Asia: Governance, institutions and urban development. Edward Elgar Publishing.
- Beatley, T. (2018). Biophilic cities: Integrating nature into urban design and planning. Island Press.
- González, J. A. (2020). Green infrastructure in urban planning: A guide for practitioners. Routledge
- Mahmood, A. (2020). Green urbanism: Formulating a sustainable urban future. Routledge.
- Roberts, P., & Sykes, O. (2018). Urban green spaces: A complete guide to parks, gardens, and other outdoor spaces in towns and cities. Routledge.

- Zhang, Y., & Lu, Y. (2021). Smart and green urban development: New concepts and strategies for sustainable mobility. Routledge.

Suggested readings

- Beatley, T. (2021). Green urbanism down under: Learning from sustainable communities in Australia. Island Press.
- Christensen, P., & Nilsson, K. (2020). Sustainable urban development: A smart and green approach to city regeneration. Palgrave Macmillan.
- Kabisch, N., Korn, H., Stadler, J., & Bonn, A. (2017). Nature-based solutions to climate change adaptation in urban areas: Linkages between science, policy and practice. Springer.
- Puppim de Oliveira, J. A. (2019). Urban sustainability in the context of climate change: Adaptation, resilience, and opportunities in cities. Springer.
- Zhang, Y. (2019). Urban regeneration and sustainability: Best practices from European cities. Routledge.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE (DSE-EVS-14): ENERGY AND ENVIRONMENT

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
DSE-EVS-14: ENERGY AND ENVIRONMENT	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Introduce fundamental concepts and principles related to the energy and environment
- Gain knowledge of the sources of energy and the impacts of its production and consumption
- Identify the technological, economic, and social perspective of energy
- Analyze the environmental and social implications of energy sources and evaluate policies related to energy for sustainable environmental practices
- Foster awareness of the interconnectedness of global energy and environmental issues

Learning outcomes:

After the course, students will be able to

- Explain the principles and concepts of energy and its impacts on environment
- Evaluate the merit and demerits of different energy sources and associated technologies
- Analyze the environmental and social implications of energy production and consumption
- Evaluate the effectiveness of policies and strategies for promoting sustainable energy and environmental practices.
- Advocate for sustainable energy and environmental practices as informed and active citizens

SYLLABUS OF DSE-EVS-14

Theory (02 Credits: 30 lectures)

UNIT – I Concepts of Energy and Environment (1 Weeks) (2 lectures)

Definition and scope of energy and environment, Types of energy and their environmental impacts, Energy production and consumption trends, Global warming and climate change, Ecological footprint, Energy and environmental policies, Environmental impact assessment, Sustainable development

UNIT – I Fossil Fuels and their Environmental Impact (1 Weeks) (2 lectures)

Coal, oil, and gas extraction and processing, Greenhouse gas emissions and climate change, Air pollution from fossil fuels, Water pollution from fossil fuels, Environmental impacts of oil spills, Acid rain, Land degradation from mining, Fossil fuel dependence and energy security

UNIT – II Renewable Energy Sources (1 Weeks) (2 lectures)

Solar energy, Wind energy, Geothermal energy, Hydroelectric power, Ocean energy, Bioenergy, Biomass and biofuels, Renewable energy technologies and their environmental impact

UNIT – III Energy Efficiency and Conservation (2 Weeks) (4 lectures)

Energy efficiency in buildings, Energy-efficient appliances and electronics, Transportation efficiency and fuel economy, Energy conservation behaviours, Energy audits and retrofits, Green building design and construction, Smart grids and energy storage, Energy-efficient lighting

UNIT – IV Energy and the Environment in Developing Countries (3½ Weeks) (7 lectures)

Energy access and poverty alleviation, Energy consumption patterns in developing countries, Clean energy technologies for developing countries, Environmental impacts of energy in developing countries, Energy and sustainable development, Energy financing and investment in developing countries, Capacity building and technology transfer, International cooperation on energy and the environment, India's efforts for a sustainable sources of energy and self-reliance

UNIT – V Environmental Impacts of Nuclear Energy (2½ Weeks) (5 lectures)

Nuclear power generation and its environmental impact, Nuclear accidents and their environmental impact, Nuclear waste management and disposal, Nuclear proliferation and security risks, Alternatives to nuclear energy, Public perception of nuclear energy, Nuclear energy and climate change, Nuclear energy policies and regulations

UNIT –VI Energy Policy and Regulation (2½ Weeks) (5 lectures)

International energy policies and agreements, National energy policies and goals, Renewable energy incentives and subsidies, Fossil fuel subsidies and taxation, Energy market regulation, Energy efficiency standards and labelling, Carbon pricing and emissions trading, Energy security and geopolitical considerations

UNIT – VII Emerging Energy Technologies and Future Prospects (1½ Weeks) (3 lectures)
Energy storage technologies, Carbon capture and storage, Artificial photosynthesis, Fusion energy, Energy from waste, Smart cities and energy systems, Future energy scenarios and modelling, Technological innovation and energy transitions

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Measure energy consumption of household appliances and calculate the energy savings from switching to energy-efficient appliances and recommend the most efficient options
2. Conduct an energy audit of a building to identify areas of energy waste in a building and recommend energy-saving measures
3. Analyze the carbon footprint of a household or business and recommend ways to reduce it
4. Evaluate the environmental impact of different waste disposal methods in your city and recommend the most sustainable options
5. Investigate the impact of water usage on the environment and energy sector and recommend ways to conserve water sustainably
6. Analyze the impact of energy policy on the environment and recommend more sustainable policies.
7. Investigate the impact of transportation choices on energy and the environment and develop a sustainable plan for the city
8. Measure the efficiency of solar panels under different light intensities and angles of incidence
9. Assess the environmental impacts of a product or process throughout its entire life cycle, from raw materials extraction to disposal.
10. Measure the concentration of different greenhouse gases in the atmosphere and track their trends over time
11. Set up to convert waste materials into energy using selected biological method(s)
12. Analyze using of electric vehicles or public transportation in your city as sustainable transportation options and evaluate their environmental impacts

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Hoffert, M. I. (2021). Energy and climate change: How to achieve a successful energy transition. Cham, Switzerland: Springer.
- Mebratu, D. (2021). Energy, environment, and sustainable development: A socio-economic approach. Abingdon, UK: Routledge.
- Smil, V. (2020). Growth: From microorganisms to megacities. Cambridge, MA: MIT Press.
- Sovacool, B. K., Heffron, R. J., & McCauley, D. (Eds.). (2020). Energy democracy: Goals and policies. Cham, Switzerland: Palgrave Macmillan.
- Westra, L., & Carbonnier, G. (2021). Energy transition, capitalism and the environment: Problems and solutions. Abingdon, UK: Routledge.

Suggested readings

- Burchell, K., & Rettie, R. (2021). Energy ethics: Conceptualizing a moral compass for energy transitions. London, UK: Palgrave Pivot.
- Levi, M. A. (2021). The power surge: Energy, opportunity, and the battle for America's future. New York, NY: Oxford University Press.
- Monbiot, G. (2021). Heat: How to stop the planet burning. London, UK: Penguin.
- Nye, D. E. (2021). Powering the new civilization: Energy, civilization, and the demands of the future. New York, NY: HarperCollins.
- Raza, S. A. (2021). The political ecology of energy transitions: A political economy approach. Abingdon, UK: Routledge.
- Rifkin, J. (2020). The Green New Deal: Why the fossil fuel civilization will collapse by 2028, and the bold economic plan to save life on Earth. New York, NY: St. Martin's Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE (DSE-EVS-15): BIOINFORMATICS & ENVIRONMENT

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
DSE-EVS-15: BIOINFORMATICS & ENVIRONMENT	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Introduce the principles of bioinformatics for environmental research
- Provide with hands-on experience of bioinformatics to analyze biological data for environmental research
- Enable to address the challenges and opportunities of using bioinformatics in environmental science
- Enable students to communicate effectively and professionally about bioinformatics research and its implications for environmental science.

Learning outcomes:

After the course, students will be able to

- Use bioinformatics to analyze biological data for environmental research
- Evaluate the quality of bioinformatics data and use it for environmental science
- Communicate effectively the use of bioinformatics for environmental protection
- Apply problem-solving skills to real-world bioinformatics and environmental research challenges
- Use environmental challenges as novel opportunities by applying bioinformatics for developing sustainable approaches for environmental protection

SYLLABUS OF DSE-EVS-15

Theory (02 Credits: 30 lectures)

UNIT – I Bioinformatics Basics (2 Weeks) (4 lectures)

Definition and Scope of Bioinformatics, Biological Data Types and Sources, Introduction to Computer Science and Mathematics for Bioinformatics, Overview of Bioinformatics Tools and Databases, Sequence Alignment and Assembly Algorithms, Phylogenetic Analysis and Molecular Evolution

UNIT – II Genomics and Transcriptomics (2½ Weeks) (5 lectures)
DNA Sequencing Technologies and Platforms, Genome Sequencing, Assembly, Annotation and Visualization, Comparative Genomics, Gene Expression Transcriptomics Analysis and Interpretation, and Epigenetics Analysis

UNIT – III Proteomics and Metabolomics (3 Weeks) (6 lectures)
Proteomics Technologies and Platforms, Protein Separation and Identification, Mass Spectrometry and Peptide Mapping, Protein-Protein Interactions and Complex Analysis, Metabolomics and Metabolic Pathway Analysis, Metabolite Profiling and Identification, Biomarker Discovery and Validation, Integration of Omics Data and Network Analysis

UNIT – IV Computational Biology and Biostatistics (1½ Weeks) (3 lectures)
Biostatistical Methods and Techniques, Hypothesis Testing and Model Selection, Regression Analysis and Linear Models, Machine Learning and Data Mining, Statistical Analysis of Biological Data

UNIT – V Systems Biology and Network Analysis (2 Weeks) (4 lectures)
Systems Biology Concepts and Approaches, Regulatory Networks and Pathways, Signaling Networks and Cell Communication, Metabolic Networks and Flux Balance Analysis, Network Visualization and Analysis

UNIT – VI Environmental Genomics and Metagenomics (4 Weeks) (8 lectures)
Environmental DNA: sampling, sequencing, and analysis; Metagenomics for: biodiversity assessment, community analysis, understand biogeochemistry, determine ecosystem functioning; and ascertain functional diversity

Bioinformatics Applications in: developing stress-tolerant crops, genomics for animal breeding, improving livestock health, management of aquaculture and fisheries, environmental monitoring, bioremediation, bioprospecting and conservation

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1-4. Familiarize with commonly used bioinformatics tools and databases, such as BLAST, ClustalW, NCBI, and UniProt

5-6. Sequence analysis and alignment of nucleotide and protein sequences and analyze their properties

1. Familarize with basics of genome annotation and comparative genomics using different software and tools

8-9. Analyze metagenomic data, identify and classify microbial communities, and explore their functional properties

10-11. Know dealing with RNA sequencing data for transcriptome analysis and explore gene expression patterns
12-13. Explore protein structure and function using different software and tools or learn basics of identification and quantification of metabolites, and exploration of metabolic pathways
14-15. Learn basic statistical techniques and perform data analysis on biological datasets, such as hypothesis testing and regression analysis,

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Bell, T., & Lilley, A. (2019). Environmental Proteomics: Methods and Protocols. Springer.
- Carvalho, R. (2019). Bioinformatics for Biologists. Wiley.
- Li, R. W. (2018). Environmental Metagenomics: Methods, Protocols, and Applications. Humana Press.
- Xia, X. (2019). Ecological Bioinformatics: The Role of Bioinformatics in Studying Ecology. Academic Press.
- Zhu, D. (2021). Environmental Bioinformatics. CRC Press.

Suggested readings

- Hirsch, A. (Ed.). (2020). Environmental DNA: A Practical Guide to Methods, Applications, and Data Analysis. Wiley.
- Liu, Z. (2020). Bioinformatics in Aquaculture: Principles and Methods. Academic Press.
- Karlovsky, P. (Ed.). (2019). Environmental Metabolomics: Methods and Protocols. Humana Press.
- Huang, X., & Madan, A. (2019). Environmental Bioinformatics. Springer.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE (DSE-EVS-16): DATA ANALYTICS FOR ENVIRONMENTAL SUSTAINABILITY

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
DSE-EVS-16: DATA ANALYTICS FOR ENVIRONMENTAL SUSTAINABILITY	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Introduce the concepts and principles of data analytics in the context of environmental sustainability
- Enable to collect, process, analyze, and visualize environmental data using appropriate software tools and techniques
- Equip to apply statistical and machine learning techniques to environmental data analysis and interpretation
- Provide practical experience in using data analytics for environmental impact assessment, carbon accounting, and waste management
- Enhance understanding of the role of data analytics in promoting sustainable development and environmental stewardship

Learning outcomes:

After the course, students will be able to

- Describe the principles and importance of data analytics for environmental sustainability
- Collect and process environmental data using appropriate software tools
- Analyze environmental data using statistical and machine learning techniques.
- Visualize environmental data using appropriate software tools and techniques
- Apply data analytics to environmental impact assessment, carbon accounting, and waste management
- Demonstrate critical thinking, problem-solving, and decision-making skills related to environmental sustainability

SYLLABUS OF DSE-EVS-16

Theory (02 Credits: 30 lectures)

UNIT – I Introduction to Environmental Sustainability and Data Analytics
(2 Weeks) (4 lectures)

Introduction to environmental sustainability, Overview of data analytics, Importance of data analytics in environmental sustainability, Data types and sources for environmental sustainability, Techniques for data analysis and interpretation, Environmental data visualization, Case studies in data analytics for environmental sustainability, Ethics of data collection and analysis in environmental sustainability

UNIT – II Environmental Data Collection and Processing (2 Weeks) (4 lectures)
Overview of environmental data collection methods, Techniques for cleaning and preprocessing environmental data, Quality assurance and quality control for environmental data, Big data and cloud computing for environmental data processing, Data warehousing and data management in environmental sustainability, Geographic information systems (GIS) for environmental data, Data integration and data fusion for environmental sustainability, Challenges and limitations of environmental data collection and processing

UNIT – III Data Analytics Techniques for Environmental Sustainability
(2 Weeks) (4 lectures)
Introduction to statistical analysis for environmental data, Regression analysis for environmental data, Time series analysis for environmental data, Spatial analysis for environmental data, Machine learning techniques for environmental data analysis, Data clustering and classification for environmental sustainability, Network analysis for environmental sustainability, Visualization techniques for environmental sustainability data

UNIT – IV Modeling and Simulation for Environmental Sustainability
(2 Weeks) (4 lectures)
Introduction to modeling and simulation in environmental sustainability, Modeling techniques for environmental sustainability, Environmental systems dynamics modelling, Agent-based modeling for environmental sustainability, System dynamics modeling for environmental sustainability, Optimization modeling for environmental sustainability, Monte Carlo simulation for environmental sustainability, Case studies in modeling and simulation for environmental sustainability

UNIT – V Environmental management and conservation using data analytics
(2 Weeks) (4 lectures)
Data analytics for: environmental impact and risk assessment, environmental regulations compliance, conservation monitoring; Case studies of using data analytics in: biodiversity conservation, and water and waste management

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Introduction to R programming for environmental data analysis
2. Cleaning and preprocessing environmental data using Excel
3. Visualization of environmental data using Tableau
4. Regression analysis for environmental data using R
5. Time series analysis for environmental data using Python

6. Spatial analysis for environmental data using ArcGIS
7. Data clustering and classification for environmental sustainability using R
8. Monte Carlo simulation for environmental sustainability using Excel
9. Environmental impact assessment using data analytics
10. Carbon accounting and management using Excel
11. Analysis of weather and climate data using Python
12. Social media analysis for environmental sustainability using Netlytic

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Cooper, J. (2016). Environmental impact assessment: A practical guide (2nd ed.). Wiley-Blackwell.
- Grolemund, G., & Wickham, H. (2018). R for data science: Import, tidy, transform, visualize, and model data. O'Reilly Media.
- James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). An Introduction to Statistical Learning: With Applications in R. Springer.
- Lawhead, J. (2018). Learning ArcGIS Pro. Packt Publishing.
- Matthews, H. D. (2020). Climate data analytics: An introductory guide. Cambridge University Press.
- Wall, D. H., & Evans, D. A. D. (2018). Environmental analytics: Methods and applications for the chemical and environmental sciences. Wiley.
- Zhang, Y., Lu, Y., & Guo, M. (2020). Big data analytics for environmental sustainability: Challenges, opportunities and practices. Springer.

Suggested readings

- Alexander, M. J., & Walkenbach, J. (2019). Excel 2019 Bible. Wiley.
- Kaufman, L., & Rousseeuw, P. J. (2009). Finding groups in data: An introduction to cluster analysis (2nd ed.). Wiley.
- Murray, S. (2020). Tableau your data!: Fast and easy visual analysis with Tableau Software. Wiley.
- Petts, J. (2018). Handbook of environmental impact assessment (2nd ed.). Wiley.
- Sleeter, B. M., & Davis, K. F. (2019). Mapping with ArcGIS Pro: Design accurate and user-friendly maps to share the story of your data. Packt Publishing.
- VanderPlas, J. (2016). Python data science handbook: Essential tools for working with data. O'Reilly Media.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE (DSE-EVS-17): ENVIRONMENTAL SUSTAINABILITY AND DATA VISUALIZATION

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
DSE-EVS-17: ENVIRONMENTAL SUSTAINABILITY AND DATA VISUALIZATION	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Develop skills in data collection, cleaning, and preparation for visualization
- Learn various data visualization techniques for environmental data analysis and communication
- Apply data analysis and visualization skills to real-world environmental sustainability problems
- Develop critical thinking skills in environmental sustainability and data visualization

Learning outcomes:

After the course, students will be able to

- Collect, clean, and prepare environmental data for analysis and visualization
- Use various data visualization techniques such as line charts, heat maps, and tree maps for environmental data analysis and communication
- Apply data analysis and visualization skills to real-world environmental sustainability problems and create compelling data visualization presentations
- Develop critical thinking skills in environmental sustainability and data visualization and evaluate the effectiveness of different visualization techniques for different audiences

SYLLABUS OF DSE-EVS-17

Theory (02 Credits: 30 lectures)

UNIT – I Introduction to Environmental Sustainability and Data Visualization
(2 Weeks) (4 lectures)

Introduction to environmental sustainability, Introduction to data visualization, Overview of environmental data sources, Role of data visualization in environmental sustainability, Basic statistical concepts, Introduction to data analysis software (e.g. Excel, R, Python), Introduction to data visualization software (e.g. Tableau, Power BI), Case studies in environmental sustainability and data visualization

UNIT – II Climate Change and Data Visualization (2 Weeks) (4 lectures)
Overview of climate change and its causes, Analysis of climate change data (e.g. temperature, carbon emissions), Visualization of climate change data (e.g. line charts, heat maps), Communicating climate change data to various audiences, Case studies in climate change data visualization

UNIT – III Resource Depletion and Data Visualization (2 Weeks) (4 lectures)
Overview of resource depletion (e.g. water, oil, minerals), Analysis of resource depletion data, Visualization of resource depletion data (e.g. bar charts, scatter plots), Communicating resource depletion data to various audiences, Case studies in resource depletion data visualization

UNIT – IV Pollution and Data Visualization (2 Weeks) (4 lectures)
Overview of pollution (e.g. air, water, soil), Analysis of pollution data, Visualization of pollution data (e.g. maps, histograms), Communicating pollution data to various audiences, Case studies in pollution data visualization

UNIT – V Biodiversity Loss and Data Visualization (2 Weeks) (4 lectures)
Overview of biodiversity loss, Analysis of biodiversity data, Visualization of biodiversity data (e.g. network graphs, tree maps), Communicating biodiversity data to various audiences, Case studies in biodiversity data visualization

UNIT – VI Sustainability in Industry and Data Visualization (2½ Weeks) (5 lectures)
Overview of sustainability in various industries (e.g. agriculture, energy, transportation), Analysis of sustainability data in industry, Visualization of sustainability data in industry (e.g. bubble charts, stacked bars), Communicating sustainability data in industry to various audiences, Case studies in sustainability data visualization in industry

UNIT – VII Communicating Environmental Data (2½ Weeks) (5 lectures)
Overview of communication strategies for environmental data, Choosing appropriate visualization types for different audiences, Design principles for effective data visualizations, Best practices for communicating environmental data, Case studies in effective communication of environmental data

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Understand the basics of data visualization and different types of charts/graphs
2. Analyze climate change data and create visualizations using line charts and heat maps
3. Examine data on resource depletion and generate visual representations using bar graphs and scatter plots.
4. Create visual representations of pollution data by using maps and histograms after examining the dataset.

5. Analyze biodiversity data and create visualizations using network graphs and tree maps.
6. Assess sustainability data across different industries and produce visualizations using stacked bars and bubble charts.
7. Design effective visualizations and communicate environmental data to various audiences.
8. Use GIS software to analyze and visualize environmental data
9. Collect environmental data from online sources using web scraping techniques.
10. Use NLP techniques to analyze environmental data from textual sources.
11. Create visualizations that support decision-making processes related to environmental sustainability.
12. Use data storytelling techniques to communicate environmental sustainability issues and solutions

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Berg, L. R., & Hassenzahl, D. M. (2016). Visualizing Environmental Science. John Wiley & Sons.
- Cairo, A. (2019). How Charts Lie: Getting Smarter about Visual Information. W. W. Norton & Company.
- Healy, K. (2018). Data Visualization: A Practical Introduction. Princeton University Press.
- Theus, M. (2019). Interactive Data Visualization: Foundations, Techniques, and Applications. Chapman and Hall/CRC.
- Tufte, E. R. (2017). The Visual Display of Quantitative Information. Graphics Press.

Suggested readings

- Baumer, B., Kaplan, D. T., & Horton, N. J. (2020). Modern Data Science with R. CRC Press.
- Handbook: Berg, L. R., & Hassenzahl, D. M. (2016). Visualizing Environmental Science. John Wiley & Sons.
- Kellner, K., & Niederer, C. (Eds.). (2019). Data Visualization in Society. Amsterdam University Press.
- Mann, D. J. (2018). Data Visualization for Social Science: A Practical Introduction with R and ggplot2. Routledge.
- Theus, M. (2019). Interactive Data Visualization: Foundations, Techniques, and Applications. Chapman and Hall/CRC.
- Wickham, H., & Grolemund, G. (2017). R for Data Science: Import, Tidy, Transform, Visualize, and Model Data. O'Reilly Media.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE (DSE-EVS-18): INTRODUCTION TO OCEANOGRAPHY

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
DSE-EVS-18: INTRODUCTION TO OCEANOGRAPHY	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Familiarize with physico-chemical, and geological characteristics of the ocean
- Gain insights into the interactions among the ocean-atmosphere-land in the background of human activities
- Emphasize the importance of the ocean for human well-being and sustainability

Learning outcomes:

After the course, students will be able to

- Assess the critical linkages among physico-chemical and geological processes occurring in the oceans
- Decipher the interactions between the ocean and Earth's components
- Analyze oceanographic data analysis and interpret it to relate it with human activities and global environmental policies
- Develop an appreciation of the relevance of oceans in society and determining global challenges

SYLLABUS OF DSE-EVS-18

Theory (02 Credits: 30 lectures)

UNIT – I Oceanography basics (2½ Weeks) (5 lectures)
Definition of oceanography, History of oceanography, Importance of oceanography, Scientific methods in oceanography, Oceanographic tools and equipment, Ocean basins and features, Ocean circulation, Oceanography career opportunities

UNIT – II Physical and chemical oceanography (3 Weeks) (6 lectures)
Properties of seawater, Ocean currents, Waves, Tides, Ocean circulation, Heat budget, Water masses, Coastal oceanography

Properties of seawater, Major ions in seawater, Nutrients, Dissolved gases, pH and ocean acidification, Biogeochemical cycles, Marine pollution, Harmful algal blooms

UNIT – III Geological and biological oceanography (3 Weeks) (6 lectures)
Plate tectonics, Seafloor, Marine sediments, Paleooceanography, Mineral resources, Coastal processes, Sea level rise due to climate change, Oceanographic data and its analysis

Marine life and ecosystems: phytoplankton, zooplankton, mammals, and fisheries; Climate change and marine ecosystems

UNIT –IV Marine ecology (2 Weeks) (4 lectures)
Marine food webs and ecosystem dynamics, Mangroves and coral reefs, seagrass beds, Deep-sea ecosystems, Marine conservation and protected areas

UNIT –V Oceanography and climate (2½ Weeks) (5 lectures)
Ocean-atmosphere interactions, Oscillations: El Niño-Southern, North-Atlantic; Monsoons and climate modelling, Hurricanes and typhoons, Climate change policy and oceanography

UNIT –VI Oceanography and human interaction (2 Weeks) (4 lectures)
Maritime history and culture, Oceanographic related: law, policy, economics, technology, education, tourism, and recreation

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Familiarize with common oceanographic equipment such as CTD, Niskin bottles, and plankton nets
2. Measure seawater temperature, salinity, and density using a CTD
3. Analyse satellite imagery for oceanographic data such as sea surface temperature and chlorophyll concentration
4. Calculate oceanographic parameters using remote sensing data
5. Measure seawater pH and carbonate chemistry using a spectrophotometer
6. Calculate pH and pCO2 values from carbonate chemistry data
7. Interpret oceanographic data and preparation of graphical presentations
8. Analyse marine resources such as fisheries and aquaculture using data from government agencies and scientific literature
9. Analysis of marine spatial planning data such as marine protected areas and shipping lanes
10. Calculate spatial distribution of marine resources and assessment of the impact of human activities on marine ecosystems
11. Analyse marine policy and law at national and international levels
12. Calculate the impact of marine policy and law on marine ecosystems and human societies

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Knauss, J. A. (2016). Introduction to Physical Oceanography (2nd ed.). Waveland Press.
- Sverdrup, K. A., Armbrust, E. V., & Armstrong, R. A. (2019). Introduction to the World's Oceans (11th ed.). McGraw-Hill.
- Talley, L. D., Pickard, G. L., Emery, W. J., & Swift, J. H. (2019). Descriptive Physical Oceanography: An Introduction (6th ed.). Academic Press.
- Thurman, H. V. (2017). Introductory Oceanography (11th ed.). Prentice Hall.
- Trujillo, A. P., & Thurman, H. V. (2021). Essentials of Oceanography (13th ed.). Pearson.

Suggested readings

- Garrison, T. (2020). Oceanography: An Invitation to Marine Science (10th ed.). Cengage Learning.
- Martin, J. H., & McCorkle, D. C. (2016). An Introduction to Oceanography (2nd ed.). Jones & Bartlett Learning.
- Pinet, P. R. (2018). Invitation to Oceanography (7th ed.). Jones & Bartlett Learning.
- Segar, D. A. (2019). Introduction to Oceanography: A Life-Earth Science Approach. Springer.
- Stewart, R. H., & Church, T. M. (2019). Oceanography and Marine Biology: An Introduction to Marine Science. Garland Science.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DEPARTMENT OF ENVIRONMENTAL SCIENCE

Category-I

SEMESTER - V

BSC (H) ENVIRONMENTAL SCIENCE

DISCIPLINE SPECIFIC CORE COURSE – 13 (DSC-EVS-13): BIODIVERSITY AND CONSERVATION

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-EVS-13: BIODIVERSITY AND CONSERVATION	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Provide fundamental principles of origin and distribution of biodiversity and its conservation
- Examine major threats to biodiversity and their impacts on ecosystems and human well-being
- Investigate the methods and strategies for conserving biodiversity, including protected areas, and sustainable management practices.
- Develop critical thinking skills and to apply scientific principles to the analysis of biodiversity and conservation issues
- Appreciate the paradigm “think globally, act locally” for a sustainable common future of humankind

Learning outcomes

After this course, students will be able to:

- Assess biodiversity and determine its significance for ecological processes
- Explain the underlying factors of generating biodiversity on Earth
- Analyze major threats to biodiversity and its links with human well-being.
- Apply scientific principles to the analysis of biodiversity and conservation issues and evaluate the methods and strategies for conserving biodiversity

- Communicate effectively about biodiversity and conservation issues to both scientific and non-scientific audiences.

SYLLABUS OF DSC-EVS-13

Theory (02 Credits: 30 lectures)

UNIT – I Levels of biological organization and biodiversity patterns (2½ Week) (5 lectures)
From genes to ecosystems; tree of life; history of character transformation; organic evolution through geographic time scale; species concept – what's in a name?; how many species are there on earth?; concept and types of speciation.

Spatial patterns: latitudinal and elevational trends in biodiversity; temporal patterns: seasonal fluctuations in biodiversity patterns; importance of biodiversity patterns in conservation.

UNIT – II Biodiversity estimation (2½ Week) (5 lectures)
Sampling strategies and surveys: floristic, faunal, and aquatic; qualitative and quantitative methods: scoring, habitat assessment, richness, density, frequency, abundance, evenness, diversity, biomass estimation; community diversity estimation: alpha, beta and gamma diversity; molecular techniques: RAPD, RFLP, AFLP; NCBI database, BLAST analyses.

UNIT – III Importance of biodiversity (2 Week) (4 lectures)
Economic values – medicinal plants, drugs, fisheries and livelihoods; ecological services – primary productivity, role in hydrological cycle, biogeochemical cycling; ecosystem services – purification of water and air, nutrient cycling, climate control, pest control, pollination, and formation and protection of soil; social, aesthetic, consumptive, and ethical values of biodiversity.

UNIT – IV Threats to biodiversity (2½ Week) (5 lectures)
Natural and anthropogenic disturbances; habitat loss, habitat degradation, and habitat fragmentation; climate change; pollution; hunting; over-exploitation; deforestation; hydropower development; invasive species; land use changes; overgrazing; man wildlife conflicts; consequences of biodiversity loss; Intermediate Disturbance Hypothesis.

UNIT – V Conservation of Biodiversity (3½ Week) (6 lectures)
In-situ conservation (Biosphere Reserves, National Parks, Wildlife Sanctuaries); Ex-situ conservation (botanical gardens, zoological gardens, gene banks, seed and seedling banks, pollen culture, tissue culture and DNA banks), role of local communities and traditional knowledge in conservation; biodiversity hotspots; IUCN Red List categorization – guidelines, practice and application; Red Data book; ecological restoration; afforestation; social forestry; agro forestry; joint forest management; role of remote sensing in management of natural resources; Conservation planning.

UNIT – VI Biodiversity in India (2½Week) (5 lectures)
India as a mega diversity nation; phytogeographic and zoogeographic zones of the country; forest types and forest cover in India; fish and fisheries of India; impact of hydropower development on biological diversity; status of protected areas and biosphere reserves in the country; National Biodiversity Action Plan.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Practice and learn different field survey methods to assess and monitor biodiversity
2. Field trip to a local conservation area to assess the plant and animal diversity
3. Identify threatened and endangered species in a given
4. Assess variations in biodiversity with different types of ecosystems around
5. Estimate biodiversity indices and comparison of biodiversity levels in different locations
6. Determine magnitude of infestation of invasive species and their possible impacts on native species in a given ecosystem
7. Identify and investigate pollinators of selected plant species in a given ecosystem
8. Study the effects of habitat fragmentation or degradation on population of selected species
9. Analyze the conservation strategies and their effectiveness in protecting biodiversity in given natural and restored ecosystems
10. Identify and document economically important species in a given ecosystem
11. Undertake field trip to a local garden/ecosystem to observe different plant species and their adaptations to their environment
12. Analyse the effects of land use change on biodiversity of a given area
13. Investigate the coexistence or competition among species in a given area and based on literature suggest the possible underlying biotic interactions
14. Develop conservation planning for target species and make informed decisions for biodiversity conservation.

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Essential/recommended readings

- Primack, R.B. (2017). Essentials of Conservation Biology (Sixth Edition). Sinauer Associates.
- Gaston, K.J. (2016). Biodiversity: An Introduction (Third Edition). Wiley-Blackwell.
- Wilson, E.O. (2016). Half-Earth: Our Planet's Fight for Life. Liveright Publishing Corporation.
- Kareiva, P., & Marvier, M. (2017). Conservation Science: Balancing the Needs of People and Nature (Second Edition). Roberts and Company Publishers.
- Koh, L.P., & Wilcove, D.S. (2016). Conservation for a New Era: Integrated Conservation Science for the 21st Century. Oxford University Press.

Suggestive readings

- Lovejoy, T.E. (2019). Biodiversity and Climate Change: Transforming the Biosphere. Yale University Press.
- Pimm, S.L. (2018). The Value of Everything: How to Save the World by Making it

Wealthier. PublicAffairs.
- Simberloff, D. (2013). The Ecology of Invasions by Animals and Plants. University of Chicago Press.
- Tallis, H. (2018). The Nature of Conservation: A Race Against Time. Island Press.
- Wilson, E.O. (2016). Half-Earth: Our Planet's Fight for Life. Liveright Publishing Corporation.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 14 (DSC-EVS-14): ORGANISMAL & EVOLUTIONARY BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-EVS-14: ORGANISMAL & EVOLUTIONARY BIOLOGY	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Gain insights into principles of evolution and its significance in shaping biological diversity on Earth
- Familiar with classification of organisms from different domains of life and their unique structure and function
- Equip with scientific methods to investigate and understand nuances of organismal and evolutionary biology
- Appreciate the linkages among ecology, conservation biology, and evolutionary biology

Learning outcomes

After this course, students will be able to

- Explain the ecological and molecular processes contributing to evolution, including natural selection, genetic drift, gene flow, and mutation
- Identify and characterize organisms belonging to different domains of life based on their major characteristics and functions
- Design and conduct experiments for better understanding on organismal and evolutionary biology
- Evolve better strategies for biodiversity conservation and improving ecosystem health while taking into account their evolutionary biology

SYLLABUS OF DSC-EVS-14

Theory (02 Credits: 30 lectures)

UNIT – I History of life on Earth and theory of evolution (3½ Week) (7 lectures)
Paleontology and evolutionary History; evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale; origins of unicellular and multi cellular organisms; major groups of plants and animals; stages in primate evolution

including Homo.

Lamarck's concept of evolution; Darwin's Evolutionary Theory: variation, adaptation, struggle, fitness, and natural selection; Mendelism; spontaneity of mutations; The Evolutionary Synthesis.

UNIT – II Evolution of unicellular life (2½ Week) (5 lectures)
Origin of cells and unicellular evolution and basic biological molecules; abiotic synthesis of organic monomers and polymers; Oparin-Haldane hypothesis; study of Miller; the first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metabolism, photosynthesis and aerobic metabolism.

UNIT – III Evolution of multicellular organisms (2½ Week) (5 lectures)
Origin of multicellularity, Cellular differentiation and specialization, Developmental biology and body plans, Evolution of cell-to-cell communication, Emergence of tissues and organs, Evolution of organ systems, Evolution of life cycles and reproductive strategies, Evolution of multicellular organisms (protists, plants and animals) and their ecological interactions

UNIT – IV Geography of evolution (1½ Week) (3 lectures)
Biogeographic evidence of evolution; patterns of distribution; historical factors affecting geographic distribution; evolution of geographic patterns of diversity.

UNIT – V Molecular evolution (2 Week) (4 lectures)
Neutral evolution; molecular divergence and molecular clocks; molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence.

UNIT – VI Fundamentals of population genetics (3 Week) (6 lectures)
Concepts of populations, gene pool, gene frequency; concepts and rate of change in gene frequency through natural selection, migration and genetic drift; adaptive radiation; isolating mechanisms; speciation (allopatric, sympatric, peripatric and parapatric); convergent evolution; sexual selection; co- evolution; Hardy-Weinberg Law.

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Analyze effects of pH on the toxicity of heavy metals on model organism, such as Daphnia

2-3. Determine toxicity of varying concentration of industrial effluent on common alga and measure its growth and survival rates

4-5. Effects of heavy metal toxicity on plant growth, focussing on different plant parts and physiological characteristics

6. Analyze effects of climate change on diversity of pollinators
7. Determine the impacts of environmental chemicals on the abundance and diversity of nematodes (e.g., *Caenorhabditis elegans*)
8. Ascertain the possible impacts of herbicides on weed populations
9. Test the effects of a target organic contaminant on behaviour and mortality of earthworm

10-11. Measure developmental abnormalities in zebrafish embryos due to toxicity of target environmental chemicals

12-13. Prepare and characterize nanoparticles of selected heavy metal and assess effect of nanoparticles on plant growth

15. Effects of various concentrations of road salt on freshwater organisms (e.g., zooplankton) and measure changes in their behavior and survival

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Futuyma, D. J., & Kirkpatrick, M. (2017). Evolution (4th ed.). Sunderland, MA: Sinauer Associates.
- Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2018). Brock Biology of Microorganisms (15th ed.). London, UK: Pearson.
- Primack, R. B., & Rodricks, R. V. (2021). Essentials of Conservation Biology (7th ed.). Sunderland, MA: Sinauer Associates.
- Raven, P. H., Evert, R. F., & Eichhorn, S. E. (2022). Biology of Plants (9th ed.). New York, NY: W. H. Freeman.
- Sodhi, N. S., Gibson, L., & Raven, P. H. (2021). Conservation Biology for All. Oxford, UK: Oxford University Press.
- Stearns, S. C., & Hoekstra, R. F. (2021). Evolution: An Introduction (3rd ed.). Oxford, UK: Oxford University Press.
- Zimmer, C., & Emlen, D. J. (2021). Evolution: Making Sense of Life. New York, NY: Macmillan Learning.

Suggestive readings

- Deacon, J. (2019). Fungal Biology (5th ed.). Hoboken, NJ: John Wiley & Sons.
- Haviland, W. A., Prins, H. E. L., Walrath, D., & McBride, B. (2021). Evolution and Prehistory: The Human Challenge (11th ed.). Boston, MA: Cengage Learning.
- Herron, J. C., & Freeman, S. (2020). Evolutionary Analysis (6th ed.). Hoboken, NJ: Pearson.

- Pough, F. H., Janis, C. M., & Heiser, J. B. (2018). Vertebrate Life (10th ed.). London, UK: Pearson.
- Raven, P. H., Johnson, G. B., Mason, K. A., Losos, J. B., & Singer, S. R. (2021). Biology (12th ed.). New York, NY: McGraw-Hill Education.
- Ruppert, E. E., Fox, R. S., & Barnes, R. D. (2021). Invertebrate Zoology: A Functional Evolutionary Approach. Boston, MA: Cengage Learning.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 15 (DSC-EVS-15): NATURAL RESOURCES MANAGEMENT & SUSTAINABILITY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-EVS-15: NATURAL RESOURCES MANAGEMENT & SUSTAINABILITY	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Gain insights into the principles and practices of natural resources management and sustainability
- Understand critical linkages among social, economic, and environmental issues related to natural resources management and sustainability
- Impart analytical and critical thinking skills related to natural resources management and sustainability
- Equip students with the knowledge and skills necessary to develop and implement sustainable solutions to natural resource management challenges
- Prepare students for careers in natural resource management, environmental policy, sustainability, and related fields

Learning outcomes

After this course, students will be able to

- Analyze the socio-economic, and environmental issues related to natural resource management
- Explain the key principles and practices of natural resource management and sustainability.
- Evaluate the effectiveness of natural resource management and sustainability policies and practices and develop sustainable solutions
- Communicate effectively about natural resource management and sustainability issues to a variety of audiences.
- Assess the environmental impacts of natural resource management and sustainability practices and apply ecological, economic an ethical principle to natural resource management and sustainability issues

- Pursue careers in natural resource management, environmental policy, sustainability, and related fields.

SYLLABUS OF DSC-EVS-15

Theory (02 Credits: 30 lectures)

UNIT – I Natural resources and reserves and their management
(3½ Weeks) (7 lectures)

Classification of natural resources, Renewable and non-renewable resources, Land resources; Soil resources, Forest resources, food resources, Water resources; Fisheries and other marine resources; energy resources; mineral resources; resource availability and factors influencing its availability; human impact on natural resources; Resource degradation; Resource conservation; Concept of natural resource management, Relationship between natural resource management and sustainability, Stakeholders and natural resource management, Social and economic dimension of resource management, Role of science and technology in natural resource management, Sustainable Development Goals (SDGs) and natural resources.

UNIT –II Land Use and Management **(2 Weeks)** (4 lectures)

Land use and land cover change, Land use planning and management, Land degradation and desertification, Soil conservation and management, Agroforestry and sustainable agriculture, Urbanization and land use, Land tights, Land use conflict and resolution

UNIT – III Mineral resources **(3 Weeks)** (6 lectures)

Mineral resources: definition, types, rock cycle, significance in society and importance economic development, Mineral extraction and processing: types of mining, techniques, methods, waste management, and social and environmental impacts, Global consumption patterns of mineral resources, techniques to increase mineral resource supplies; ocean mining for mineral resources, Mineral markets and economics, Mineral governance and policy, Sustainable mineral resource management, Future of mineral resources

UNIT – IV Non-renewable and renewable energy resources (3½ Weeks) (7 lectures)

Oil, coal natural gas liquified natural gas: formation, reserve, exploration, extraction and processing, and consumption; Environmental and economic impacts of non-renewable energy consumption;

Solar energy, hydropower, geothermal energy, tidal energy, wave energy, ocean thermal energy, nuclear power, biomass and biofuel: technology, potential, operational costs, advantages, challenges, innovation and future; Radioactive contamination; Application of green technology; India's efforts and its global impacts on solar mission, Indian renewable energy programme, Future energy options and challenges.

UNIT – V Resource management for sustainability (3 Weeks) (6 lectures)

Approaches in Resource Management: ecological, economic, and ethnological, Implications of integrated resource management; Climate Change and Energy Management: energy sources, efficiency and conservation, carbon capture and storage;

Urban Ecosystems: energy efficiency, transportation, industry, and reduction in greenhouse gas emissions; Energy policy and governance.

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Identify, classify and assess the status of different tree species in a given ecosystems and recommend appropriate management strategies
2. Investigate the effects of different land management practices on soil erosion to understand how to prevent soil degradation and protect natural resources
3. Test the water quality of given water samples collected from two water bodies and suggest appropriate management practices
4. Survey and document the socio-economic and ecological importance of plant species sampled from a local ecosystem
5. Assess the current status of plant species prioritized in practical 4 and recommend the appropriate conservation and management practices
6. Calculate and interpret the ecological footprint of a community or organization using the Ecological Footprint Standards.
7. Conduct energy audits of buildings or facilities using standard methods such as the ASHRAE Level I, II, or III Energy Audits.
8. Analyze stakeholders to identify and engage with key stakeholders in natural resources management and sustainability.
9. Conduct life cycle assessment of products or processes using standard methods such as the ISO 14040/14044 standards
10. Document agricultural research priorities of India and comment on its importance as sustainable agricultural practices for natural resource management and food security
11. Develop and implement a sustainable plan for water resource management of your institute
12. Assess the environmental impacts of mining activities in India during past 10 years and identify the shift in trend, if any
13. Analyze mineral/energy resource policies in a national or global context to understand the importance of sustainable mineral resource management.
14. Extract bioenergy from organic waste or crops to understand the importance of renewable energy sources and their management.

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Cleveland, C. J. (2018). Biophysical economics: From physiocracy to ecological economics and industrial ecology. Routledge.
- Folke, C., Österblom, H., Jouffray, J. B., Lambin, E. F., & Adger, W. N. (Eds.). (2020). For ocean sustainability: Challenges, opportunities, and the role of science-policy interaction. Cambridge University Press.
- Mitchell, B. (2019). Resource efficiency and sustainable production: A handbook for achieving sustainability in manufacturing. Springer.
- Reed, M. G. (2021). Environmental and natural resource economics: A contemporary approach. Routledge.
- Varghese, J. (2019). Resource management for sustainable development. Springer.

Suggestive readings

- Agyeman, J. (Ed.). (2020). Sustainability: A handbook for management and leadership. Routledge.
- Daly, H. E. (Ed.). (2017). Valuing the Earth: Economics, ecology, ethics. MIT Press.
- Norton, B. G. (2018). Sustainability: A philosophy of adaptive ecosystem management. University of Chicago Press.
- Westman, W. E. (Ed.). (2018). How much is enough? Shaping the defense program, 1961-1969. Routledge.
- Wright, T. (2020). Sustainable communities and urban housing: A comparative analysis of self-help housing practices in the United States and Mexico. Routledge.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE (DSE-EVS-05): WATERSHED MANAGEMENT

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
DSE-EVS-05: WATERSHED MANAGEMENT	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Familiarize with the concepts of watershed management and its relevance in ecological balance
- Gain insights into various physico-chemical, and biological processes related to watersheds and its impact on water quality and quantity
- Empower with tools and methods widely used in watershed management, such as remote sensing and GIS
- Understand the legal and regulatory frameworks governing watershed management at different levels (local, state, and national)

Learning outcomes

After the course, the students will be able to

- Explain the concept of a watershed and its importance in maintaining ecological balance
- Describe the various physical, chemical, and biological processes occurring in watersheds and their impact on water quality and quantity
- Use remote sensing, GIS, and modeling tools to analyze and manage watersheds.
- Identify and explain the legal and regulatory frameworks governing watershed management at the local, state, and national levels
- Evaluate the effectiveness of a watershed management plan through critical analysis of case studies and practical exercises
- Critically evaluate case studies in watershed management to understand challenges and opportunities in the field

SYLLABUS OF DSE-EVS-05

Theory (02 Credits: 30 lectures)

UNIT – I Watershed Management Basics (2½ Weeks) (05 lectures)
Watershed: definition, and characteristics: Watershed Management: approaches, principles, planning, importance, institutional and legal framework, role in sustainable development, and challenges and opportunities

UNIT – II Watershed Hydrology (2 Weeks) (04 lectures)
Precipitation and its measurement, Evaporation and transpiration, Infiltration and percolation, Runoff generation and calculation, Streamflow and stream gauging, Watershed models and simulations, Hydrologic design of watershed management practices, Impacts of climate change on watershed hydrology

UNIT – III Water Quality in Watershed (1½ Weeks) (03 lectures)
Water quality parameters and standards, Sources of water pollution, Point and non-point source pollution, Water quality monitoring and sampling, Water quality modeling

Eutrophication and harmful algal blooms, Water quality management practices, Watershed management for drinking water supply

UNIT – IV Land Use in Watersheds (2½ Weeks) (05 lectures)
land use and land cover change, Land use planning and zoning, Soil erosion and sedimentation, Agricultural management practices for soil and water conservation, Forest management for watershed protection, Urbanization and watershed management, Wetland conservation and management, Mining and watershed management

UNIT – V Management Practices for Sustainable Watershed Management (2 Weeks) (04 lectures)
Best management practices (BMPs), Conservation tillage and crop rotation, Agroforestry and silvopasture, Riparian buffer management, Grassland management, Land treatment and land application, Green infrastructure and low-impact development (lid), Restoration of degraded watersheds

UNIT – VI Watershed Economics (2½ Weeks) (05 lectures)
Economic valuation of watershed services, Benefit-cost analysis of watershed management projects, Water pricing and market-based mechanisms for watershed management, Environmental economics and watershed management, Cost-effective watershed management, Watershed financing and investment, Economic instruments for watershed conservation, Watershed management and rural livelihoods

UNIT –VII Stakeholder Participation and Governance in Watershed Management

(2 Weeks) (04 lectures)
Community-based watershed management, Public participation and stakeholder engagement, Social equity and environmental justice, Governance structures and watershed management, Water user associations (WUAs), Secentralization and devolution of watershed management, Indigenous knowledge and watershed management, Gender and watershed management

UNIT – VIII Case Studies in Watershed Management (1½ Weeks) (03 lectures)
Case studies on: success and failures of watershed management, from developing countries, influence by and adaptation to climate change conflicts and resolution, and ecological restoration; Watershed management and sustainable development goals

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Delineate and categorize watershed boundary using digital elevation data and GIS software
2. Calibrate and validate the model by collecting data on climate, land use, soil properties, and topography of the watershed
3. Set up the model in the chosen software by defining the watershed boundary, hydrological processes, and inputs and outputs of the model
4. Conduct a sensitivity analysis to identify the most important model parameters that affect the model's output
5. Document prevalence of invasive species in two most significant watershed regions of India
6. Design and suggest best management practices (BMPs) of world’s most notable watershed region and compare it with any watershed region of India
7. Analyze different types of satellite imagery and their use in watershed management
8. Determine the impact of changes in land use and land cover on water quality and watershed management
9. Create a hydrological model of a watershed using remote sensing and GIS, simulating runoff, soil erosion, and other hydrological processes
10. Map wetlands in a watershed using remote sensing and GIS and analyze their functions, such as water storage, nutrient cycling, and biodiversity conservation
11. Determine soil erosion rates in a watershed using remote sensing and GIS and analyze their impact on water quality, sedimentation, and flooding

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available

data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Anderson, C. W., & Miller, W. W. (2021). Watershed management: Planning for the 21st century. John Wiley & Sons.
- Bruijnzeel, L.A., Hamilton, L.S., and Asdak, C. (2011). Rainforest Hydrology, Ecology and Management. Springer.
- Dupigny-Giroux, L. A., McCabe, G. J., & Hirsch, R. M. (2017). State of the art in watershed modeling. John Wiley & Sons.
- King, K.W., Balogh, J.C., and Harmel, R.D. (2010). Watershed Management for Potable Water Supply: Assessing the New York City Strategy. American Society of Agricultural and Biological Engineers.
- National Research Council. (2008). Urban Stormwater Management in the United States. National Academies Press.
- Tindall, J.A., Keren, R.A., and Stone, J.J. (2016). Watershed Management: Planning for the 21st Century. American Society of Civil Engineers.

Suggestive readings

- Ma, J., Su, C., and Liu, W. (Eds.). (2018). River basin management in the twenty-first century: Understanding people and place. CRC Press.
- Miao, S. L., Zhang, C., Cai, Y., & Zhou, J. (Eds.). (2022). Sustainable watershed management in China. Springer.
- Water Environment Federation. (2012). Urban Watersheds: Geology, Contamination, and Sustainable Development. Wiley.
- Wilcock, R.J., and Iverson, R.M. (2013). Surface Water-Quality Modeling. Waveland Press.
- Yang, H. (2010). Integrated Watershed Management in the Global Ecosystem. Nova Science Publishers.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-EVS-6): WETLAND CONSTRUCTION AND MANAGEMENT

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
DSE-EVS-6: WETLAND CONSTRUCTION AND MANAGEMENT	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Understand physical and chemical processes for classifying, segregating, and managing solid wastes
- Characterize the different solid waste types and apply interdisciplinary knowledge for effective solid waste collection and processing of solid waste
- Compare methods of collection, transfer, storage, treatment, disposal, and use of solid waste in developed and developing nations
- Management, construction, and operations of landfill and other solid waste management facilities

Learning outcomes

After successful completion of this course, students will be able to:

- Conduct the life cycle assessment of solid waste and its impact on the urban metabolisms
- Identify and select landfill sites using GIS and other analytical techniques
- Examine and apply technical and legal solutions for sustainable management of solid waste
- Plan and design waste recycling programmes, compost and incineration facilities, and landfills
- Mine and analyze the relevant data and apply multiple criteria decision-making systems for a sustainable integrated solid waste management plan

SYLLABUS OF DSE-EVS-06

Theory (02 Credits: 30 lectures)

UNIT – I Wetlands Basics (1½ Weeks) (3 lectures)
Wetlands: definition, classification, functions and values, ecology and hydrology, ecosystem services; Importance in global environment, Wetland plant and animal communities, Wetland biogeochemistry, Threats to wetlands and wetland conservation

UNIT – II Design and Construction of Wetlands (2 Weeks) (4 lectures)
Design and planning principles, Construction techniques and materials, Wetland hydrology and water management, Vegetation selection and planting methods, Soil preparation and amendment, Erosion and sediment control, Monitoring and maintenance of constructed wetlands, Case studies in wetland design and construction

UNIT – III Restoration, Creation, and Wetland Management in Practice (3 Weeks) (6 lectures)
Restoration and creation goals and objectives, Site assessment and planning, Hydrological restoration techniques, Vegetation establishment and management, Wildlife habitat restoration and management, Monitoring and adaptive management of wetland restoration projects, Wetland restoration and creation in urban areas, Case studies in wetland restoration and creation,

Wetland management for: biodiversity conservation, water quality improvement, climate change adaptation and mitigation, and flood control and stormwater management; Challenges and opportunities for wetland management and restoration

UNIT – IV Monitoring and Assessment of Wetlands (2½ Weeks) (5 lectures)
Monitoring and assessment goals and objectives, Indicators of wetland health and function, Methods for measuring wetland hydrology, Vegetation sampling and analysis, Wildlife monitoring and assessment, Water quality monitoring, Data management and analysis, Case studies in wetland monitoring and assessment

UNIT – V Socio-Economic Benefits of and Emerging Issues in Wetland Management (3½ Weeks) (7 lectures)
Economic valuation of wetland services, Wetland-based: livelihoods, tourism, recreation and sustainable development, Wetlands and cultural heritage, Stakeholder engagement in wetland management, Social equity considerations in wetland management

Climate change impacts on wetlands, Innovative wetland management and restoration techniques, Role of wetlands in green infrastructure, and social justice, Wetland management and restoration in the developing world andthe Anthropocene, and Policy and research needs for wetland management and restoration

UNIT – VI Wetland Regulations and Policy (2½ Weeks) (5 lectures)
Wetland regulatory frameworks in India and other developed countries, Wetlands (Conservation and Management Rules) 2017, Wetland impact assessment, Ramsar Convention and international wetland protection, Wetland mitigation banking, Adaptive management for wetland restoration, Legal and ethical considerations in wetland management

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Conduct a wetland site assessment and identify wetland vegetation, soils, and hydrological features
2. Analyze a wetland construction project and learn about the methods and materials used in wetland construction
3. Monitor wetland using specific indicators including vegetation characteristics and water quality
4. Identify a suitable site and develop a wetland restoration project based on theoretical concepts
5. Analyze wetland conservation policy and its relations with other environmental and biodiversity conservation policies and regulations
6. Develop and implement a wetland education and outreach program for a local community
7. Calculate water budget of a selected wetland in your area or from any other parts of the country
8. Survey a local wetland and identify characteristics plants using field guides and manuals
9. Document wetland specific wildlife, including birds, amphibians, and reptiles,
10. Analyze wetland soil samples for key soil physico-chemical properties
11. Map wetlands in your city using GIS mapping and assess the ecosystem diversity
12. Conduct a wetland education program and evaluate its effectiveness in promoting importance of wetlands

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Brinson, M. M., & Rheinhardt, R. D. (2017). The practice of wetland restoration. American Society of Civil Engineers.
- Craft, C. B., Seneca, E. D., & Broome, S. W. (2018). Methods in biogeochemistry of wetlands. Soil Science Society of America.
- Lewis, J. (Ed.). (2018). Wetlands law and policy: understanding regulatory and environmental challenges. American Bar Association.
- Richardson, C. J. (Ed.). (2019). The wetland book: I: structure and function, management and methods (2nd ed.). Springer.
- Vymazal, J. (2018). Constructed wetlands for wastewater treatment: municipal, industrial and agricultural. Elsevier.

Suggestive readings

- Middleton, B. A. (2018). Wetland restoration: flood pulsing and disturbance dynamics (2nd ed.). Island Press.
- Millennium Ecosystem Assessment. (2005). Ecosystems and human well-being: wetlands and water synthesis. World Resources Institute.
- Mitsch, W. J., & Gosselink, J. G. (2015). Wetlands (5th ed.). John Wiley & Sons.
- Richardson, C. J., & King, R. S. (2019). Understanding and managing freshwater wetlands (2nd ed.). CRC Press.
- Zedler, J. B., & Kercher, S. (Eds.). (2015). Wetland restoration and construction: a technical guide (2nd ed.). CRC Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE (DSE-EVS-7): WATER TREATMENT TECHNOLOGIES

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
DSE-EVS-7: WATER TREATMENT TECHNOLOGIES	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Gain insights into physico-chemical, and biological processes involved in water treatment
- Familiarize with different types of water treatment technologies and their applications
- Understand the importance of water quality standards and learn criteria to evaluate the effectiveness of water treatment processes
- Identify and appreciate the critical linkages among environmental, socio-economic impacts of water treatment and importance regulations

Learning outcomes

After the course, students will be able to:

- Explain the performance of water treatment plant based on the physico-chemical, and biological processes
- Apply theoretical concepts for operation, management, and improvement of water treatment systems
- Evaluate the effectiveness of water treatment plants and its link with socio-economic and environmental impacts
- Collaborate for learning the structure and function of local water treatment plants to solve related problems

SYLLABUS OF DSE-EVS-7

Theory (02 Credits: 30 lectures)

UNIT – I Fundamentals of Water Treatment Technologies (1½ Weeks) (3 lectures)

Water sources: types, quality parameters, different uses; Water treatment processes: overview, types, importance in public health; Water treatment plants: design, operations, maintenance, future trends; Regulations and standards

UNIT – II Pre-Treatment and primary treatment processes (3½ Weeks) (7 lectures)

Screening and sedimentation, Adsorption and absorption, Coagulation and flocculation, Chemical dosing, pH control methods, Aeration and degasification, Membrane filtration and reverse osmosis

Sedimentation and clarification, Dissolved air flotation and gravity separation, Hydrocyclone and centrifugation methods, Physical and chemical disinfection, UV irradiation and ozonation, Chlorination and chloramination, Taste and odor control methods, Color removal and demineralization techniques

UNIT – III Secondary Treatment Processes (2½ Weeks) (5 lectures)

Biological treatment methods, Activated sludge: aerobic and anaerobic digestion; Bioreactors, Nutrient: removal, denitrification, and recovery techniques; Sludge dewatering and drying methods, Biofilm and trickling filters, Constructed wetlands and bioswales

UNIT – IV Tertiary Treatment Processes (2½ Weeks) (5 lectures)

Advanced oxidation processes, Granular activated carbon and adsorption beds, Ion exchange and membrane technologies, Electrocoagulation and electrochemical treatment, Chemical precipitation and coagulation-flocculation, Disinfection byproduct removal and control, Emerging contaminants and micropollutants, Industrial wastewater treatment methods

UNIT – V Water Distribution Systems (2½ Weeks) (5 lectures)

Water distribution systems: overview, and components; Pipeline materials and design considerations, Pumping stations and pressure regulation, Storage tanks and reservoirs, Water quality monitoring and testing, Water loss and leak detection, Cross-connection control and backflow prevention

UNIT – VI Water Treatment Plant Management (2½ Weeks) (5 lectures)

Water treatment plant performance metrics, Safety and emergency response planning, Human resources and staffing, Asset management and maintenance, Energy management and optimization, Capital and budgeting planning, Public outreach and Regulatory compliance

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Visit local water treatment plant and understand its structure and function and link it with the efficacy of water treatment
2. Analyze the water samples collected from local water treatment plant at different stages of treatment and analyze the role of ongoing physico-chemical and biological processes
3. Based on analyses of practicals 1 and 2, prepare a plan for improvement of water treatment plant with appropriate justification
4. Assess efficacy of filtration by different media, including sand, activated carbon, and gravel in removing contaminants from water
5. Prepare and test the potential of biofilters to remove nutrients and organic matter from water.
6. Ascertain the requirement and assess the effectiveness of chlorination for disinfection of microbial contaminated water samples
7. Test the effectiveness of coagulation-flocculation in removing suspended particles from water and determine effectiveness of different coagulants and flocculants
8. Determine the sedimentation rate of suspended particles in water using graduated cylinders packed with different soil particle size fractions
9. Determine effectiveness of UV radiation and ozone treatment in reducing the microbial load in water samples.
10. Assess the effectiveness of reverse osmosis in treating the water loaded with salts and other contaminants and improving the water quality
11. Determine the effectiveness of activated carbon and other self-prepared biological sorbent in reducing the chemical oxygen demand (COD)

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Crittenden, J. C., Trussell, R. R., Hand, D. W., Howe, K. J., & Tchobanoglous, G. (2012). MWH's Water Treatment: Principles and Design (3rd ed.). John Wiley & Sons.
- Farooq, R., & Fan, J. (2020). Water Treatment Technologies for the Removal of High-Toxicity Pollutants. Elsevier. https://doi.org/10.1016/C2019-0-03681-3
- Johnson, L. (2021). Emerging Water Treatment Technologies. Boca Raton, FL: CRC Press.

- Kim, S. (2021). Sustainable Water Treatment Technologies. Amsterdam, Netherlands: Elsevier.
- Zhang, Q. (2020). Innovative Water Treatment Technologies. Singapore: Springer.

Suggestive readings

- Brown, R. (2020). Membrane-Based Water Treatment Technologies. Hoboken, NJ: Wiley.
- Chen, X., Li, Y., & Li, P. (2021). Environmental Water Treatment Technologies: Advanced Treatment Processes, Modeling and Optimization. Elsevier. https://doi.org/10.1016/C2021-0-03457-3
- Chen, W. (2019). Advanced Oxidation Technologies for Water and Wastewater Treatment. Springer.
- Davis, M. L., & Masten, S. J. (2018). Principles of Environmental Engineering and Science (3rd ed.). McGraw-Hill Education.
- Smith, J. (2022). Advanced Water Treatment Technologies. New York, NY: Springer.
- Tchobanoglous, G., Burton, F. L., & Stensel, H. D. (2013). Wastewater Engineering: Treatment and Resource Recovery (5th ed.). McGraw-Hill Education.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE (DSE-EVS-8): ENVIRONMENTAL ENGINEERING

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
DSE-EVS-8: ENVIRONMENTAL ENGINEERING	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Gain insights into the principles and practices of environmental engineering and develop skills in the environmental systems and technologies
- Cultivate skills for effective awareness for the environmental impacts of human activities and foster critical thinking in the context of sustainable development
- Evaluate tools and techniques, such as mathematical-, experimental-, and computer-based, used in environmental engineering
- Equip with laboratory techniques for estimating quality of water, air and waste

Learning outcomes:

After the course, students will be able to

- Apply principles of environmental engineering into environmental systems and technologies
- Analyze and design environmental systems for treating water, controlling air pollution and manage waste
- Evaluate the environmental impacts of human activities, and appreciate ethical and professional responsibilities of environmental engineers for sustainability
- Demonstrate proficiency in the use of environmental engineering tools and technologies for sustainable development

SYLLABUS OF DSE-EVS-8

Theory (02 Credits: 30 lectures)

UNIT – I Basics of Environmental Engineering (2 Weeks) (4 lectures)

Environmental Engineering: concept, history and evolution, potential in sustainable development; Green chemistry and life cycle assessment, Ethics and environmental policies and regulations, Chemistry of water, air and soil, Redox reactions and chemical equilibrium, Biological processes and environmental functioning (photosynthesis, respiration, decomposition, nutrient cycling)

UNIT – II Water and Wastewater Treatment (2½ Weeks) (5 lectures)
Water and wastewater treatment methods: physical, chemical, biological, integrated and advanced methods; Water quality: parameters, standards, and related regulations; Sludge: treatment, use, and disposal; Water reuse and recycling

UNIT – III Air Pollution Control (2½ Weeks) (5 lectures)
Air quality: parameters, standards, and regulations; Air Pollutants: types, sources, dispersion, and their control; Indoor air quality, Emerging air pollutants

UNIT – IV Solid Waste Management (2½ Weeks) (5 lectures)
Solid waste: types, characteristics, collection, transportation, storage, processing, treatment, and disposal or resource recovery and recycling; Integrated solid waste management; Hazardous waste management

UNIT – V Microbial and plant biology and ecology (2½ Weeks) (5 lectures)
Microbial and plant physio-ecological processes and waste treatment, Ecophysiology of microbes and plants, Growth of microbes and plants during waste management, Pathogen control in soil, water, and air by biological methods

UNIT – VI Environmental Impact Assessment (EIA) (1½ Weeks) (3 lectures)
EIA: Process, Statement, and case studies; Social and Economic Impact Assessment, Environmental Management Plan

UNIT – VII Sustainable Energy and Climate Change (1½ Weeks) (3 lectures)
Sustainable Energy and Climate Change: renewable energy sources, energy efficiency, climate change science, case studies, Climate change: mitigation and adaptation strategies, Carbon footprinting

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1-3. Conduct physico-chemical characterization of given water samples (pH, temperature, dissolved oxygen, turbidity, total suspended solids, and NO3-N or PO4-P)
4. Characterize the given wastewater sampled from an industry and agricultural field
5. Measure the concentration of particulate matter, NO2, SO2, CO, using different methods
6. Characterize solid waste and determine its moisture content, density, and calorific value

7. Visit a landfill site and draw its design and explain the underlying geotechnical principles
8. Based on practical 5, improve and propose a design and justify the improvement in the design
9. Test the ability of given bacteria to tolerate different levels of the selected pollutants
10. Select and evaluate a proposed project or activity using life cycle assessment
11. Perform a life cycle assessment of a selected product or process and determine its possible environmental impacts from cradle to grave
12. Using principles of green chemistry, perform the selected experiment using environmentally friendly methods and reagents

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Chiang, C. Y., & Lin, Y. P. (2021). Sustainable Environmental Engineering: Trends and Innovations. Elsevier.
- Gribb, M., & Banerjee, S. (2021). Environmental Engineering: Principles and Practice. Cambridge University Press.
- Kharaghani, A., & Fazeli, A. (2021). Environmental Engineering and Management: Sustainable Development and Hazard Mitigation. CRC Press.
- Vesilind, P. A., & Morgan, S. M. (2020). Introduction to Environmental Engineering. Cengage Learning.
- Wang, Y. (2020). Environmental Engineering: An Introduction to the Fundamentals. Wiley.

Suggested readings

- Falletti, L., & Paolini, R. (2019). Environmental Remediation Technologies for Metal-Contaminated Soils. Springer.
- Lichtfouse, E. (2020). Environmental Chemistry for a Sustainable World. Springer.
- Shuyler, H. (2021). Sustainability and Engineering: Concepts, Metrics, and Opportunities. Springer.
- Tchobanoglous, G., & Burton, F. L. (2019). Wastewater Engineering: Treatment and Resource Recovery. McGraw-Hill Education.
- Wang, L. K., Hung, Y. T., & Shammas, N. K. (2016). Advanced Treatment Technologies for Urban Wastewater Reuse. Springer.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVES (DSE-EVS-9): NATURAL HAZARDS & DISASTER MANAGEMENT

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
DSE-EVS-9: NATURAL HAZARDS & DISASTER MANAGEMENT	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Gain insights into the types and causes of natural hazards and their potential impacts on individuals and communities.
- Examine the socio-economic, and environmental factors contributing to disaster risk and vulnerability
- Identify principles of disaster risk reduction and management, including mitigation, preparedness, response, and recovery.
- Understand different perspectives of disaster management, including ethical social and cultural
- Analyze the critical linkages between climate change and natural hazards and prepare plans for disaster preparedness, emergency response and recovery

Learning outcomes

After successful completion of this course, students will be able to:

- Identify a specific risk of natural hazards to the given locality or community conduct a hazard assessment and identify potential weaknesses in disaster preparedness of a local community or infrastructure
- Develop an emergency preparedness plan for their residential colony highlighting evacuation routes, emergency contacts, and supplies
- Design a communication plan for disaster response and recovery operation and develop a disaster risk reduction plan for mitigation, preparedness, response, and recovery
- Evaluate the relevance of GIS mapping, remote sensing, and social media in disaster response and recovery plans and examine the associated issues, such as equity, justice, and human rights

SYLLABUS OF DSE-EVS-09

Theory (02 Credits: 30 lectures)

UNIT – I Natural Hazards and Disasters Basics (2½ Weeks) (5 lectures)
Natural hazards and disasters: definition, classification (geological, meteorological, hydrological, biological), causes (plate tectonics, climate change, etc.), social and economic effects; Historical and recent natural disasters and their impacts, Disaster risk reduction and management frameworks, International disaster response mechanisms, Disaster preparedness and mitigation strategies

UNIT – II Geological Hazards (2 Weeks) (4 lectures)
Earthquakes: causes, prediction and warning systems, Seismic hazards and risk assessment, Tsunamis: causes and early warning systems; Volcanic hazards and eruptions: risk assessment and mitigation strategies; Landslides: causes and impacts

UNIT – III Meteorological Hazards (2 Weeks) (4 lectures)
Causes and impacts of: hurricanes, typhoons, cyclones, tornadoes, thunderstorms and lightning, floods and flash floods, drought, heat waves, wildfires; Climate change and its impact on meteorological hazards

UNIT – IV Hydrological Hazards (2 Weeks) (4 lectures)
Causes and impacts of: river flooding, coastal flooding and storm surges, dam and levee failures, urban flooding, groundwater depletion and contamination; Water scarcity and its effects on society, Water management and conservation strategies, Climate change and hydrological hazards

UNIT – V Biological Hazards (2 Weeks) (4 lectures)
Pandemics and epidemics, Zoonotic diseases and their transmission, Vector-borne diseases and their prevention, Foodborne diseases and their causes, Bioterrorism and its impacts, Environmental health and its relationship to natural hazards, Health systems and emergency response to biological hazards, One Health approach to disaster management

UNIT – VI Technological Hazards (2 Weeks) (4 lectures)
Causes and consequences of hazards, such as: industrial accidents, nuclear accidents, chemical spills, transportation accidents, and cybersecurity threats; Communication technologies and their role in disaster response, Technological risk assessment and mitigation strategies, Relationship between technological hazards and natural hazards

UNIT – VII Disaster Response and Recovery: Policy and ethics (2½ Weeks) (5 lectures)
Emergency response, Disaster recovery and reconstruction, Psychological impacts of disasters, Gender and disaster response, Social vulnerability and disaster risk reduction, Community resilience and disaster preparedness, Role of government and international community

Disaster risk reduction policies and frameworks, Environmental ethics and human rights in disaster response and recovery, and disaster management, Stakeholder engagement public-private partnerships, Legal frameworks and liability, Innovation and technology in future

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Conduct a hazard assessment of your college or a given locality or local community to identify the vulnerability to most likely natural hazards and its potential impacts
2. Develop an emergency preparedness plan for the area investigated in practical 1, highlighting evacuation routes, emergency contacts, and supplies
3. Conduct a disaster simulation exercise in the area selected in practicals 1 and 2 to practice emergency response skills
4. Analyze disaster preparedness plan of a local community or infrastructure, assess vulnerability, and identify potential weaknesses for improvement
5. Analyze a recent case study of natural disaster from India or the country of your choice and critically evaluate its socio-economic impacts, including effects on housing, healthcare, and employment
6. Design a communication plan for an effective disaster response and recovery operation,
7. Develop a plan to reduce the risk of disasters for a community giving details of mitigation, preparedness, response, and recovery
8. Analyze the risk of a critical infrastructure system of your city including transportation network or power grid and identify vulnerabilities and potential consequences of failure
9. Examine the climate change scenarios and assess the potential for increased frequency and intensity of natural hazards in a given area
10. Analyze a recent case study on natural disaster and evaluate the emerging importance of technology use in disaster response and recovery, including GIS mapping, remote sensing, and social media
11. Identify the populations vulnerable to possible natural disasters in an area and develop a specific plan for the preparedness of low-income communities, elderly populations, and people with disabilities
12. Analyze different components of Community Emergency Response Team (CERT) training or community-based disaster preparedness programme

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available

data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Birkmann, J., Cardona, O. D., & Carreño, M. L. (2018). Risk Analysis of Natural Hazards: Interdisciplinary Challenges and Integrated Solutions. Springer.
- Cutter, S. L. (2019). Hazards, Vulnerability and Environmental Justice. Routledge.
- Dash, N. (2018). Climate Change and Disaster Risk Management. CRC Press.
- Keller, E., DeVecchio, D., & Galloway, D. (2021). Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes. Pearson.
- Musaazi, M., Cunha, R., & Kibreab, M. (2019). Disaster Risk Reduction and Management Approaches. Springer.
- Smith, K. (2019). Environmental Hazards: Assessing Risk and Reducing Disaster. Routledge.

Suggestive readings

- Berke, P. R., & Beatley, T. (2017). Planning for Resilience: Handbook for Practitioners. Island Press.
- Comfort, L. K. (2019). Crisis Management and Emergency Planning: Preparing for Today's Challenges. Routledge.
- Li, J., & Chen, Y. (2021). Risk Management of Natural Disasters: A Comparative Study of the Role of Governments. Springer.
- Okuyama, S., & Chang, R. (2018). Managing Natural Disasters through Public-Private Partnerships. Springer.
- Wisner, B., Gaillard, J. C., & Kelman, I. (2019). The Routledge Handbook of Disaster Risk Reduction Including Climate Change Adaptation. Routledge.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DEPARTMENT OF ENVIRONMENTAL SCIENCE

Category-I

SEMESTER - VI

BSC (H) ENVIRONMENTAL SCIENCE

DISCIPLINE SPECIFIC CORE COURSE – 16 (DSC-EVS-16): ENVIRONMENTAL POLLUTION AND HUMAN HEALTH

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-EVS-16: ENVIRONMENTAL POLLUTION AND HUMAN HEALTH	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Provide in-depth knowledge about pollution sources, and its effects on human health
- Equip with skills to assess and manage pollution related health risks
- Enable to analyze the roles government agencies, industry, and the public, in protecting environment and human health
- Familiarize with the advancements in research and technology to control environmental pollution and protect human health
- Encourage to apply skills and knowledge to real-world problems of environmental pollution and human health

Learning outcomes

After this course, students will be able to:

- Identify different types and sources of environmental pollutants and associated impacts on human health
- Use analytical techniques to monitor environmental pollutants in air, water, and soil
- Assess the health risks associated with exposure to different pollutants and recommend appropriate strategies to manage associated risks
- Recommend appropriate scientific analysis related to environmental health, risks and solutions to decision-makers

SYLLABUS OF DSC-EVS-16

Theory (02 Credits: 30 lectures)

UNIT – I Introduction **(1 Week)** (2 lectures)

Environmental pollutants and their classification, Link between pollution and human health, Ecological principles and pollution, Environmental health risk assessment, Global perspectives on pollution and health, Ethics and social responsibility in pollution management

UNIT – II Air pollution **(2½ Week)** (5 lectures)

Ambient air quality: monitoring and standards (National Ambient Air Quality Standards of India); air quality index; sources and types of pollutants (primary and secondary); smog (case study); effects of different pollutants on human health (NOx, SOx, PM, CO, CO2, hydrocarbons and VOCs) and control measures; indoor air pollution: sources and effects on human health.

UNIT – III Water pollution **(3 Week)** (6 lectures)

Sources of surface and ground water pollution; water quality parameters and standards; organic waste and water pollution; eutrophication; COD, BOD, DO; effect of water contaminants on human health (nitrate, fluoride, arsenic, chlorine, cadmium, mercury, pesticides); water borne diseases; concept and working of effluent treatment plants (ETPs).

Marine resources and their importance; sources of marine pollution; oil spill and its effects; coral reefs and their demise; coastal area management; existing challenges and management techniques (planning, construction, environmental monitoring of coastal zones).

UNIT – IV Soil pollution **(1 Week)** (2 lectures)

Causes of soil pollution and degradation; effect of soil pollution on environment, vegetation and other life forms; control strategies.

UNIT – V Noise, radioactive and thermal pollution **(2½ Week)** (5 lectures)

Noise pollution – sources; frequency, intensity and permissible ambient noise levels; effect on communication, impacts on life forms and humans - working efficiency, physical and mental health; control measures.

Radioactive material and sources of radioactive pollution; effect of radiation on human health (somatic and genetic effects); thermal pollution and its effects.

UNIT – VI Chemistry of environmental pollutants **(2½Week)** (5 lectures)

Solubility of pollutants (hydrophilic and lipophilic pollutants), transfer of pollutants within different mediums, role of chelating agents in transferring pollutants, concept of biotransformation and bioaccumulation, concept of radioactivity, radioactive decay and half-life of pollutants, organometallic compounds, acid mine drainage.

UNIT – VII Pollution control **(2½Week)** (5 lectures)

Activated Sludge Process (ASP) – Trickling Filters – oxidation ponds, fluidized bed reactors, membrane bioreactor neutralization, ETP sludge management; digesters, up flow anaerobic sludge blanket reactor, fixed film reactors, sequencing batch reactors, hybrid reactors, bioscrubbers, biotrickling filters; regulatory framework for pollution monitoring and control; case study: Ganga Action Plan; Yamuna Action Plan; implementation of CNG in NCT of Delhi.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1-3. Determine the levels of selected gaseous pollutants (oxides of nitrogen and sulfur, carbon monoxide) and particulate matter
4. Analyze National Ambient Air Quality Standards (NAAQS) of your City and compare it with any other city of similar size and demography from the country or other parts of the world
5-7. Analyze quality of water sampled from different sources based on pH, dissolved oxygen, turbidity, and nutrient contents
8. Analyze the most probable soil pollutants of area near your college and predict its impact on human health
9. Identify health hazard by any target air/water pollutant of your city and develop the possible exposure pathway and predict the associated environmental health risk
10. Assess potential of water pollution control techniques like coagulation-flocculation, sedimentation, filtration, and disinfection
11. Measure the noise levels in different environments using sound level meters and analyze the impacts of noise pollution on human health
12. Determine the probable indoor air pollutants in the buildings of your college and identify their sources
13. Analyze the cases of waterborne Disease during past 30-years in any country of your choice and determine the pattern, if any
14. Practice different communication strategies for educating the pollution-related health hazards and assess their impacts

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Essential/recommended readings

- Brauer, M., & Brook, J. (Eds.). (2019). Air pollution and health (2nd ed.). Academic Press.
- Gee, D. (2019). Toxic legacy: Synthetic toxins in the food, water and air of American cities. MIT Press.
- Gee, D. (2019). Toxic legacy: Synthetic toxins in the food, water and air of American cities. MIT Press.
- Harrison, R. M. (2019). Pollution: Causes, effects and control (5th ed.). Royal Society of Chemistry.
- Lippmann, M. (2019). Environmental toxicants: Human exposures and their health

effects (4th ed.). John Wiley & Sons.
- Merchant, R. M. (2019). An introduction to environmental epidemiology. CRC Press.
- World Health Organization. (2019). Chemicals of public health concern: Fact sheets. World Health Organization.
- Yang, Y., & Khudyakov, J. I. (Eds.). (2020). Environmental surveillance and population monitoring for chemical, biological, and radiological agents. Academic Press.

Suggestive readings

- Clements, A. L. (2019). Green building: Guidebook for sustainable architecture. Routledge.
- Cohen, A. J. (2017). The human cost of air pollution: Health implications for billions of people. The MIT Press.
- Guha, M., & Sircar, N. (Eds.). (2019). Environmental hazards in South Asia: Domestic and transboundary perspectives. Routledge.
- Peterson, R. E. (2019). The fundamentals of environmental chemistry. CRC Press.
- Ritz, B. (2019). Critical windows of exposure to environmental pollutants. Springer.
- White, L. W., & Gibson, J. E. (2019). Principles of toxicology: Environmental and industrial applications (3rd ed.). John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 17 (DSC-EVS-17): ENVIRONMENTAL LEGISLATION & POLICY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-EVS-17: ENVIRONMENTAL LEGISLATION & POLICY	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Provide an overview of the key environmental laws, regulations, and policies of India and world
- Examine the role of government agencies, stakeholders, and the public in the environmental policy-making process.
- Explore the historical development and contemporary challenges of environmental policy and its implementation.
- Analyze the impact of environmental policies on environmental quality, public health, and social justice.

Learning outcomes

After this course, students will be able to

- Describe the key environmental laws, regulations, and policies of India and world, including their history and objectives
- Analyze the roles of government agencies, stakeholders, and the public in the environmental policy-making process, and understand the challenges and opportunities in policy implementation
- Evaluate the effectiveness of environmental policies in achieving their intended outcomes, including their impacts on environmental quality, public health, and social justice
- Communicate their understanding of environmental policy issues and solutions to a variety of audiences, including policymakers, stakeholders, and the public.

SYLLABUS OF DSC-EVS-17

Theory (02 Credits: 30 lectures)

UNIT – I Introduction (3½ Week) (7 lectures)

Constitution of India; fundamental rights; fundamental duties; Union of India; union list, state list, concurrent list; legislature; state assemblies; judiciary; panchayats and municipal bodies; National Green Tribunal.

UNIT – II History of environmental legislation and policy (2½ Week) (5 lectures)
Ancient period: worship of water, air, trees; Mauryan period: Kautilya's Arthashastra, Yajnavalkyasmriti and Charaksamhita; Medieval period: forests as woodland and hunting resourcesduring Mughal reign; British India: Indian Penal Code 1860, Forest Act 1865, Fisheries Act 1897; Independent India: Van Mahotsava 1950, National Forest Policy 1952, Orissa River pollution and prevention Act 1953.

UNIT – III Environmental legislation (2½ Week) (5 lectures)
Legal definitions (environmental pollution, natural resource, biodiversity, forest, sustainable development); Article 48A (The protection and improvement of environment and safeguarding of forests and wildlife); Article 51 A (Fundamental duties).

UNIT – IV Legislative Instruments (1½ Week) (3 lectures)
The Indian Forest Act 1927; The Wildlife (Protection) Act 1972; The Water (Prevention and Control of Pollution) Act 1974; The Forests (Conservation) Act 1980; The Air (Prevention and Control of Pollution) Act 1981; The Environment (Protection) Act 1986; Motor Vehicle Act 1988; The Public Liability Insurance Act 1991; Noise Pollution (Regulation and Control) Rules 2000; The Biological Diversity Act 2002; The Schedule Tribes and other Traditional Dwellers (Recognition of Forests Rights) Act 2006; The National Green Tribunal Act 2010; Scheme and labeling of environment friendly products, Ecomarks.

UNIT – V India's recent efforts (1½ Week) (3 lectures)
Namami Gange Programme 2014, National Mission on Sustainable Agriculture 2014, Smart Cities Mission 2015, Plastic Waste Management Rules of 2016, National Policy on Marine Fisheries of 2017, National Clean Air Programme 2019, Jal Shakti Abhiyan 2019, Swachh Bharat Abhiyan 2.0, EIA Notification 2020, National Biodiversity Act of 2022.

UNIT – VI Government institutions and case studies (2 Week) (4 lectures)
Role of Ministry of Environment, Forests & Climate Change in environmental law and policy making; role of central and state pollution control boards in environmental law and policy making.

National Green Tribunal: Aditya N Prasad vs. Union of India & Others; Ganga Tanneries Case: M.C. Mehta vs. Union of India 1988; Environmental education case: M.C. Mehta vs. Union of India, WP 860/1991.

UNIT – VII International laws and policy (3 Week) (6 lectures)
Stockholm Conference 1972; Ramsar Convention, Montreal Protocol 1987; United Nations Conference on Environment and Development 1992; Rio de Janeiro (Rio Declaration, Agenda 21); Kyoto Protocol 1997; Copenhagen and Paris Summits; The Sustainable Development Goals 2015, and The Basel Convention Plastic Waste Amendments 2019,

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Conduct a stakeholder analysis of an environmental policy issue in your community to understand the range of interests and perspectives of stakeholders in environmental policy-making
2. Analyze a recent environmental impact statement (EIS) for a proposed development project
3. Develop a compliance checklist for a specific environmental regulation to understand the key requirements of an environmental regulation and ensure compliance
4. Conduct a cost-benefit analysis of a proposed environmental policy
5. Develop a communications plan for an environmental advocacy campaign
6. Analyze a landmark environmental court case and its implications for policy-making
7. Develop a policy brief on an emerging environmental issue. Aim to effectively communicate the key facts and policy options related to an emerging environmental issue
8. Analyze the policy-making process for a recent environmental regulation to understand the key stages and actors involved in environmental policy-making
9. Conduct a comparative analysis of environmental policies in two different countries
10. Analyze the role of civil society in environmental policy-making, especially of non-governmental organizations, and other stakeholders
11. Conduct a stakeholder analysis of issues of climate change or biodiversity loss, or marine conservation

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Alexander, L. (2018). Environmental law: Cases and materials. West Academic

Publishing.
- Christoff, P. (2018). Fourteen environmental reformers: Speaking up for nature. Routledge.
- Donnelly, K. (2019). Environmental law, policy, and economics: Reclaiming the environmental agenda. Routledge.
- Fisher, E. (2019). Environmental law: A very short introduction. Oxford University Press.
- Hird, J. A. (2019). Pollution, politics, and international law: Tankers at sea. Routledge.
- Lavanya, R. (2021). Environmental law in India: An introduction to legal principles, policy and practice. Bloomsbury Publishing.
- Menon, M. K. (2020). Environmental law and policy in India. Springer.

Suggestive readings

- Bhaskar, V. (2019). Environmental law and policy in India: Trends, issues and challenges. Springer.
- Fisher, E. (2018). Regulating chemicals: Law, science, and the unbearable burdens of regulation. Routledge.
- Gunningham, N. (2015). Smart regulation: Designing environmental policy. Oxford University Press.
- Kramer, R., & Leape, J. (Eds.). (2018). Legal and policy tools for the transition to sustainable societies: Regional pathways to green economy. Routledge.
- Sutherland, E. H. (Ed.). (2020). Handbook of international environmental law (2nd ed.). Edward Elgar Publishing.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 18 (DSC-EVS-18) URBAN ECOSYSTEMS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-EVS-18: URBAN ECOSYSTEMS	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Gain insights into the concepts and principles of sustainability of urban ecosystems and development
- In-depth understanding of the interactions in socio-ecological systems in urban settings
- Equip with skills to analyze urban environmental problems and provide effective solutions
- Encourage to critically evaluate policies and practices related to urban ecosystems and suggest ecologically sound alternative strategies
- Foster appreciation for urban biodiversity and ecosystems and its linkages with human well-being and social equity

Learning outcomes

After this course, students will be able to

- Explain key concepts of urban ecosystems and its linkages with sustainable urban development.
- Analyze interactions between socio-ecological systems in urban settings and its impacts on ecosystem services
- Apply socio-ecological methods to assess urban environmental problems, including pollution, water scarcity and habitat fragmentation
- Recommend green urban development strategies, such as green infrastructure, and ecosystem-based adaptation
- Communicate the relevance of urban biodiversity with reference to human well-being and social equity

SYLLABUS OF DSC-EVS-18

Theory (02 Credits: 30 lectures)

UNIT – I Introduction to Urban Ecosystems **(3½ Weeks)** (7 lectures)
Definition and scope of urban ecosystems, Historical and cultural contexts of urbanization, Ecological approach to urban systems, Urbanization process and its impacts on ecosystems, Concept of sustainability and its application to urban ecosystems, Urban environmental issues and challenges, Methods and tools for studying urban ecosystems, Urban ecosystem services and benefits

UNIT – II Urban Ecology and Biodiversity **(3½ Weeks)** (7 lectures)
Principles of urban ecology, Biodiversity in urban ecosystems, Urban habitats and their characteristics, Ecological interactions in urban ecosystems, Species adaptation and evolution in urban environments, Urban wildlife and conservation, Urban agriculture and gardening, Urban forestry and green infrastructure

UNIT – III Urban Hydrology and Water Management **(3½ Weeks) (7 lectures)**
Urban water cycle, Water demand and supply in urban areas, Stormwater management and green infrastructure, Water quality and pollution control, Groundwater management in urban areas, Urban wetlands and their functions, Water conservation and efficiency in urban areas, Water governance and policy in urban areas

UNIT – IV Urban Air Quality and Pollution **(3½ Weeks) (7 lectures)**
Sources and types of urban air pollution, Health effects of urban air pollution, Atmospheric chemistry and pollution transport, Air quality monitoring and modelling, Urban heat island effects and mitigation, Energy and transportation systems and air pollution, Indoor air quality in urban areas, Policy and regulation for air quality in urban areas

UNIT – V Urban Waste Management and Recycling **(3½ Weeks) (7 lectures)**
Urban waste generation and composition, Waste reduction and recycling strategies, Municipal solid waste management and disposal, Hazardous waste management in urban areas, Electronic waste and recycling, Construction and demolition waste management, Composting and organic waste management, Waste-to-energy and alternative waste management technologies

UNIT – VI Urban Land Use and Planning **(3½ Weeks) (7 lectures)**
Urban land use patterns and dynamics, Urban sprawl and its impacts, Smart growth and compact cities, Sustainable urban development and planning, Land use regulations and zoning, Brownfields and urban redevelopment, Transit-oriented development and walkability, Public participation and community-based planning

UNIT – VII Urban Social and Economic Systems (3½ Weeks) (7 lectures)

Urbanization and Urban Demography linked with: social diversity, homelessness, inequality and poverty, education and workforce, health, entrepreneurship, innovation and well-being

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Assess magnitude of urban heat island effects and the role of urban forests in mitigating them
2. Quantify the ecological and economic benefits of urban trees and understand the importance of urban forestry
3. Assess the impact of urbanization on soil quality and understand the principles of soil health in urban landscapes
4. Analyze the impact of urbanization on water quality and understand the principles of stream health in urban environments
5. Determine the effects of urbanization on bird populations and understand the importance of bird conservation in urban areas
6. Identify opportunities for green infrastructure improvements in a neighborhood and understand the principles of green infrastructure planning and implementation
7. Quantify the economic benefits of urban agriculture and understand the principles of sustainable food systems.
8. Determine the effects of air pollution on plant health and understand the impact of air pollution on urban ecosystems
9. Examine the impact of urbanization on insect populations and understand the importance of insect biodiversity in urban areas
10. Analyze the impact of urbanization on carbon cycling and understand the role of urban ecosystems in climate change mitigation.
11. Assess the impact of urbanization on amphibian populations and understand the importance of amphibian conservation in urban environments
12. Determine the effects of urbanization on soil microbial communities and understand the role of soil microbiota in urban ecosystems
13. Design and implement a green infrastructure project for a specific urban site or neighborhood and understand the principles of green infrastructure planning and implementation.

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Colding, J. (2018). Ecological Landscapes in the Anthropocene. Cambridge University Press.
- Colding, J., & Barthel, S. (2021). Urban Greening for Health and Well-Being. Cambridge University Press.
- McDonnell, M. J., & Hahs, A. K. (2020). Ecology of Cities and Towns: A Comparative Approach. Cambridge University Press.
- Miller, J. R. (2019). The Nature of Cities: The Ecological Imperative in Urban Design and Planning. Routledge.
- Wu, J., & Zhang, Y. (2020). Urban Ecology: An Introduction. Springer.
- Zhang, Y. (2019). Urban Ecosystems: Ecological Principles for the Built Environment. Routledge.

Suggestive readings

- Andersson, E., Barthel, S., & Borgström, S. (Eds.). (2020). Urban Ecosystems: Ecological Principles for the Built Environment. Cambridge University Press.
- Escobedo, F. J., Clerici, N., & Staudhammer, C. L. (Eds.). (2019). The Urban Forest: Cultivating Green Infrastructure for People and the Environment. Springer.
- Heynen, N. (2019). The Political Ecology of Green Spaces. Routledge.
- Kowarik, I., & Körner, S. (Eds.). (2019). Wild Urban Woodlands: New Perspectives for Urban Forestry. Springer.
- Li, Y. (2018). Sustainable Cities and Communities Design Handbook: Green Engineering, Architecture, and Technology. Butterworth-Heinemann.
- Schellnhuber, H. J., & Grimm, N. B. (Eds.). (2018). Urban Planet: Knowledge Towards Sustainable Cities. Cambridge University Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER –IV

BSc. (Polymer Science)

Bhaskaracharya College of Applied Science

DISCIPLINE SPECIFIC CORE COURSE – 10

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
POLYMER TESTING AND SPECIFICATIONS (PTS)	4	2	0	2	Class 12th with Physics, Chemistry, Mathematics	NIL

Learning objectives

The Learning Objectives of this course are as follows:

- To learn about the fundamentals of polymer testing
- To understand testing standards of polymeric materials on various testing instruments

Learning outcomes

The Learning Outcomes of this course are as follows:

After completing the course, the students

- Perform tests of polymeric materials on testing instruments
- Establish the structure property correlation (mechanical, thermal, optical, electrical) of polymers
- Elucidate stability of various polymers and their properties on the basis of their thermo mechanical transitions.

SYLLABUS OF DSC- 10

THEORY COMPONENT-

UNIT 1: (12 Hours)

TESTING STANDARDS AND MECHANICAL ANALYSIS OF POLYMERS

Principles of standardization, preparation of sample, different standards: BIS and ASTM standards (thermal and mechanical analysis), testing methods, evaluation of errors in polymer testing, correction of errors

a. Short term strengths: tensile, flexural, hardness, impact strength, tear resistance, abrasion, etc.

b. Long term strengths: Creep and fatigue properties, isochronous stress strain curve compression set.

UNIT 2: **(4 Hours)**

ELECTRICAL AND OPTICAL PROPERTIES

Dielectric strength, surface and volume resistivity, electro active properties, Refractive index, Haze and gloss, yellowness index.

UNIT 3: **(6 Hours)**

GAS BARRIER AND ENVIRONMENTAL ASSESSMENT

Permeability to gases and moisture: Standard methods of measuring the permeability of gases, Environment resistance: Cause of deterioration of polymer by aging & weathering, assessment of deterioration, natural and artificial weathering, chemical resistance.

UNIT 4: **(8 Hours)**

THERMAL AND FIRE RESISTANT PROPERTIES

Thermo-mechanical Properties, Melt flow index, thermal conductivity, thermal diffusivity, specific heat capacity, linear thermal expansion, brittleness temperature etc. Burning behaviour, flammability tests (UL-94, limiting oxygen index, critical temperature index, smoke density).

PRACTICAL COMPONENT **(60 Hours)**

- To determine the melt flow index of LLDPE, PP etc.
- To evaluate limiting oxygen index (LOI)/ UL-94 of plastic samples: PVC, PE, PP etc.
- To determine the heat distortion temperature (HDT) & vicat softening point (VSP) of polymers.
- To measure the abrasion resistance of polymer sheets.
- To measure the dielectric strength of polymer films/sheets.
- To determine the coefficient of friction of polymeric samples.
- To determine the Izod impact strength of polymeric samples.

- To determine the environment stress cracking resistance of PE/PP.
- To calculate weight percentage of inorganic and organic ingredients in polymeric compounds.
- Measure the Thermo-mechanical transition.
- Determine the water vapor transition rate for polymeric film.
- Determine the thermal conductivity of a polymer sheet.

ESSENTIAL/RECOMMENDED READINGS

- Shah V., (2007) Handbook of Plastic Testing & Technology, Wiley-Inter science.
- Hylton D., (2004) Understanding Plastic Testing, Hanser publication
- Grellmann W., Seidler S., (2013) Polymer Testing, Hanser publication.
- Willard H.H., Merrit L.L., Dean J.A. (1988) Instrumental method of analysis, Wads worth Publishing Company.
- Seidel, A. (Ed.). (2008). Characterization analysis of polymers. Wiley-Interscience.
- Pethrick, R. A., & Viney, C. (2003). Techniques for polymer organization and morphology characterisation. Wiley.
- Frick. A., Stern. C. , Muralidharan V. (2019) Practical Testing And Evaluation Of Plastics, Wiley,

SUGGESTIVE READINGS

- Berins M. L., (1991) SPI Plastic Engineering Hand book, Springer.
- Ward I.M., Sweeney J., (2004) An Introduction to the Mechanical Properties of Solid Polymers, Wiley.
- Tanaka T., (1999) Experimental Methods in Polymer Sciences, Academic Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 11

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
POLYMER PROCESSING TECHNOLOGY	**4**	**2**	**0**	**2**	**Class 12^{th} with Physics, Chemistry, Mathematics**	**---**

Learning objectives

- To learn about the various processing techniques and their components
- To learn the fundamentals of extrusion and different extrusion processes of thermoplastics.

Learning outcomes

After studying this paper, students will be able to

- Explain the significance of the single screw and multiple screw extruder systems
- Apply the fundamentals of injection and compression molding process and interpret processing variables for upgradation of quality of products

SYLLABUS OF DSC- 11

THEORY COMPONENT-

UNIT 1: (6 Hours)

EXTRUSION

Extrusion process, the extrusion die, classification of extrusion dies: film and sheet extrusion, multi-layer extrusion, Spider die, Pipe and Tube die, offset die, etc. Die swell and die defects

UNIT 2: (10 Hours)

INJECTION & BLOW MOLDING

Principles, material used, injection molding cycle, injection molding machine, some aspects of product quality, reaction injection molding (RIM), blow molding, extrusion blow molding, injection blow molding, stretch blow molding, blow moulding of PET, trouble shooting operations.

UNIT 3: (4 Hours)

THERMOFORMING

Thermoforming process: Principles, materials used, types and applications

UNIT 4: (4 Hours)

COMPRESSION & TRANSFER MOLDING

Compression moulding process, transfer moulding process: introduction, material used, types and applications

UNIT 5: (6 Hours)

MISCELLANEOUS PROCESSING METHODS

Casting and rotational moulding processes: principles, material used, types and applications
Casting, rotational moulding, machining and joining processes: principles, material used, types and applications

PRACTICAL COMPONENT (60 Hours)

- To prepare a polymeric sheet/ specimen by compression molding.
- To prepare polymeric specimens by transfer molding.
- Preparation of polymeric specimens/product by injection molding.
- To process a polymer using extruder and to determine the production rate & residence time
- To prepare polymer film/ membrane by solution casting method.
- To prepare thermo formed polymeric products.
- To cast various products using polyester resin/epoxy resin/latex.
- Industrial/lab visit.

ESSENTIAL/RECOMMENDED READINGS

- Strong A.B., (2005) Plastics: Materials & Processing, Prentice Hall.
- Rosato D.V., Rosato D.V., (2000) Injection Moulding Handbook, CBS Publisher.
- Morton-Jones D.H., (2007) Polymer Processing, Chapman & Hall.
- Griff A. L., (2021) Plastics Extrusion Technology, Creative Media Partners, LLC

- Gogos, C. G., & Tadmor, Z. (2013). Principles of polymer processing. John Wiley & Sons.
- Berins, M. (Ed.). (1991). Plastics engineering handbook of the society of the plastics industry. Springer Science & Business Media.

SUGGESTIVE READINGS

- Chan I. Chung, Hanser Verlag (2000) Extrusion of Polymers: Theory and Practice,
- R. J. Crawford, Rotational Molding of Plastics ABS, Research Studies Press Ltd.
- Crawford R.J., (1998) Plastic Engg, Butterworth-Heinemann.
- J.L. Throne (1987) Thermoforming Hanser Publishers.
- Rosato (1987) Blow Molding Handbook, Hanser Publishers.
- Harper, C. A., & Petrie, E. M. Plastic materials and processes: a concise encyclopedia. 2003.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 12

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RECYCLING AND WASTE MANAGEMENT	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry, Mathematics**	**NIL**

Learning objectives

- To introduce the concept of life cycle analysis
- To learn about the solid waste management policies
- To learn about various sources of polymer waste generation and their management
- To understand various waste disposal and treatment methods

Learning outcomes

After studying this paper, students will be able to

- Explain the policies and legislations related to polymeric waste management and their impact on environment
- Apply the 4 R's approach (reduce, reuse, recycle, recover) for solid waste management

SYLLABUS OF DSC-12

THEORY COMPONENT-

UNIT 1: **(10 Hours)**

INTRODUCTION TO WASTE MANAGEMENT

Introduction to the concept of life cycle analysis, four pillars of LCA, plastic wastes and litter, social and environmental challenges of plastic waste recycling in India, Main features of Plastic waste management regulations in India, sorting techniques and classification (density - float sink and froth floatation methods, selective dissolution, optical, spectroscopic, sorting by melting temperature, triboelectric separator etc.).

UNIT 2: **(6 Hours)**

CLASSIFICATION OF WASTE MANAGEMENT

Thermoplastic waste management: 4 R's approach (reduce, reuse, recycle, recover), recycling classification - primary, secondary, tertiary, quaternary recycling with examples (mechanical, chemical and thermal processes)

UNIT 3: **(4 Hours)**

DISPOSAL AND WASTE TREATMENT TECHNIQUES

Controlled tipping, pulverization, composting, incinerators, pyrolysis, gasification, on-site disposal methods, compacting and baling

UNIT 4: **(5 Hours)**

THERMOPLASTIC RECYCLING

Recycling of polyolefins, PVC, PET, polystyrene, polyamides (nylon-6 and nylon-6, 6) etc.

UNIT 5: **(5 Hours)**

WASTE MANAGEMENT OF THERMOSET

Recycling of thermosets, reclaiming of rubber, tire retreading, uses of recycled rubber

PRACTICAL COMPONENT (60 Hours)

- Primary recycling of various waste collected from the environment.
- Secondary recycling of MSW by incorporating and blending the recyclable waste with virgin polymers.
- To study composting of natural/biopolymers.
- Separation of polymer mixture by sink flotation technique.
- Separation of polymer mixture by selective dissolution technique.
- To recover BHET from PET by chemical recycling process
- To recover adipic acid from nylon 66 by chemical recycling technique
- To study the effect of vulcanized rubber at varying ratio (in powder form) on mechanical properties of rubber vulcanizate
- To study the effect of vulcanized rubber at varying ratio (in powder form) on thermal properties of rubber vulcanizate
- To study the effect of vulcanized rubber at varying ratio (in powder form) on physical properties of vulcanized rubber

ESSENTIAL/RECOMMENDED READINGS

- Hawkins W. L., (1984) Polymer Degradation and Stabilization, SpringerLink.
- Reich L., Stivala S. S., (1971) Elements of Polymer Degradation, McGraw-Hill.
- Niti Aayog (2021), Undp Handbook on Sustainable Urban Plastic Waste Management
- Saha N. C., Garg M., Sadhu S. D., Ghosh A. K., (2022) Food Packaging-Materials, Techniques and Environmental Issues, Springer.
- Chandra R., Adab A., (2004) Rubber and Plastic Waste: Recycling, Reuse and Future Demand, CBS Publisher.
- NIIR Board of Consultant and Engineers, (2007) Medical, Municipal and Plastic Waste Management Handbook, National Institute of Industrial Research.
- Goodship V., (2007) Introduction to plastics recycling, Rapra.

SUGGESTIVE READINGS

- Maharana, T., Negi, Y. S., & Mohanty, B. (2007). Recycling of polystyrene. Polymer-Plastics Technology and Engineering, 46(7), 729-736.
- Caillol, S. (2014). Lifecycle assessment and green chemistry: a look at innovative tools for sustainable development. Environmental Impact of Polymers, 65-89.

- Klöpffer, W. (Ed.). (2014). Background and future prospects in life cycle assessment. Springer Science & Business Media.
- Dimitris, S., & Achilias, L. (2014). Recent advances in the chemical recycling of polymers (PP, PS, LDPE, HDPE, PVC, PC, Nylon, PMMA). Mater. Recycl. Trends Perspect, 3, 64.
- La Mantia, F. (2002). Handbook of plastics recycling. iSmithers Rapra Publishing.
- Braun, D. (2002). Recycling of PVC. Progress in polymer science, 27(10), 2171-2195.
- Scheirs J., (1998) Polymer Recycling, John Wiley & Sons.
- Blow S., (2000) Handbook of Rubber Technology, Hanser Gardner.
- Bandrup J.E., (1996) Recycling and Recovery of Plastics, Hanser Gardner.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER-V

BSc. (Hons.) Polymer Science

DISCIPLINE SPECIFIC CORE COURSE – 13

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
FIBRE SCIENCE	4	2	0	2	Class 12^{th} with Physics, Chemistry, Mathematics	-

Learning objectives

- To study the basic concepts of natural and synthetic fibres
- To learn about the basic concepts of spinning including melt and solution spinning.
- To understand various parameters affecting spinning, drawing and heat setting of fibre structure and properties

Learning outcomes

After studying this paper, students will be able to

- Explain classification, structure and properties of natural and synthetic fibres
- Manufacture fibre with desired properties.
- Explain the various spinning variables

SYLLABUS OF DSC-13

UNIT 1: (4 Hours)

INTRODUCTION TO FIBRES

Introduction, classification, structural requirements of fibre forming polymers, general properties of fibres such as moisture absorption, fineness (tex, denier), tensile properties (elongation at break, elastic recovery, tenacity etc.)

UNIT 2: **(5 Hours)**

NATURAL FIBRES

Brief introduction to structure, properties and application of naturally occurring fibres: vegetable fibres, animal fibres and mineral fibres

UNIT 2: **(10 Hours)**

FIBER SPINNING PROCESSES

Melt spinning process: Spinning line, spinning manifold, spinning pack and manifold, cooling system, spinning variables, Force balance and heat balance in melt spinning; fibre structure development:

Solution spinning process: dry spinning (dope, spinning process, fibre cross section formation) wet spinning (solution preparation, coagulation, effect of process parameters on coagulation and structure of dry and wet spun fibres)

UNIT 3: **(12 Hours)**

SYNTHETIC FIBRES

Structure, properties and applications of synthetic fibres: viscose rayon, cellulose acetate, nylon 6, nylon – 66, polyester, acrylic, carbon fibre and aramid fibres

PRACTICAL COMPONENT **(60 Hours)**

(Students are required to minimum 6 experiments)

- To determine fineness (denier, tex and count) of given fibre, filaments and yarns.
- To study the cross-sectional view of natural and synthetic fibres and to identify them.
- To study the longitudinal view of natural and synthetic fibres and to identify them.
- To investigate moisture regain of fibres by absorption and desorption method.
- To identify fibres through elemental analysis.
- To identify the fibre through solubility tests.
- To analyze the reaction fibres to heat & flame.
- Analysis of chemical structure of fibres by FTIR and UV spectroscopy.
- To study thermal degradation of fibers through Thermo Gravimetric Analysis TGA method.
- To determine composition of fibres in blends.
- To measure electrical resistance of fibres.
- To measure static electricity a static charge in fibres

- To analyze microscopic properties of fibre.
- Quantitative analysis of cellulose/polyester blends.
- R & D Lab visit

ESSENTIAL/RECOMMENDED READINGS

- Cook J.G., (2009), Hand Book of Textile Fibres, Woodhead Publishing.
- Mishra S. P., (2000), A Text Book of Fibre Science and Technology, New Age International Publisher.
- Sperling L. H., (2013), Introduction to Physical Polymer Science, Wiley, 4th Edition
- Gupta V.B., Kothari V.K., (1997) Manufactured Fibre Technology, 1st Ed Chapman and Hall.
- Vaidya A.A., (1988) Production of Synthetic Fibres, First Edition, Prentice Hall of India.

SUGGESTIVE READINGS

- Morton W.E., Hearle J.W.S., (2008) Physical Properties of Fibres, Woodhead Publishing.
- David S. R., (2000) Structure Formation in Polymeric Fibres, First edition, Hanser Publishers.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 14

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
POLYMER CHARACTERIZATION	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry, Mathematics**	**-**

Learning objectives

- To acquaint the students with the instrumental techniques and their applications in characterization of polymers and polymeric materials
- To determine a chemical property and identify a chemical structure of a polymer.

Learning outcomes

After studying this paper, students will be able to

- Explain the basic principle and application of characterisation techniques.
- Interpret NMR, Raman, Mass and IR–Spectra for characterization of molecular structure of polymeric materials
- Elucidate stability of various polymers and their characterization on the basis of their thermal stability and glass transition temperature

SYLLABUS OF DSC-14

THEORY COMPONENT

UNIT 1: **(4 Hours)**

INTRODUCTION

Basic principle of spectroscopy, molecular, atomic and electronic spectra, Lambert-Beer's law, Frank-condon principle, electromagnetic radiation and it's properties, interaction of radiation with matter, statistical method of analysis.

UNIT 2: **(5 Hours)**

SPECTROSCOPIC TECHNIQUES

Principles and applications in structural determination of polymers (functional group, tacticity, molecular structure, purity, unsaturation etc.) by Infra-red spectroscopy, UV-Vis spectroscopy, electron spin resonance (ESR), raman spectroscopy, nuclear magnetic resonance spectrometer (^{1}HNMR).

UNIT 3: (5 Hours)

CHROMATOGRAPHY TECHNIQUES IN POLYMER

Paper chromatography, thin layer chromatography, high performance liquid chromatography, gel permeation chromatography (GPC), gas chromatography and size exclusion chromatography.

UNIT 4: (6 Hours)

MICROSCOPIC AND X-RAY TECHNIQUES

Optical microscopy, electron microscopy (SEM, TEM, AFM) and XRD: basics principle and applications in polymers characterization, Contact angle and measurement.

UNIT 5: (6 Hours)

THERMO-MECHANICAL CHARACTERIZATION

Principle and applications of Thermal gravimetric analysis (TGA), Differential thermal analysis (DTA). Differential scanning calorimeter (DSC), Dynamic mechanical analyser (DMA) and thermal mechanical analyser (TMA) in polymer analysis.

UNIT 6: (4 Hours)

MOLECULAR MASS AND MASS SPECTROSCOPY

Mass spectroscopy, Gas chromatography-mass spectrometer (GC-MS): principle and application for determination of molecular mass and chemical structure of polymers.

PRACTICAL COMPONENT (60 Hours)

- To verify Lambert-Beer's law by UV-Vis. spectrophotometer.
- Calculate weight percentage of inorganic and organic ingredient in polymeric compound.
- Analyze thermal behaviour of polymers by TGA.
- Quantitative determine of chemical impurities in polymer sample by UV-Vis. spectrophotometer.
- Contact angle and measurement of polymer

- Identification of additives present in a processed polymer by Paper and thin layer chromatography.
- Separation, characterization, and purity determination of polymers by TLC and Paper chromatography.
- Determination of size and particle distribution of additive in polymer sample by optical microscope.
- Determine the size and prepare size distribution curve by microscopy
- Visit of analytical laboratory.

ESSENTIAL/RECOMMENDED READINGS

- Willard H.H., Merrit L.L., Dean J.A. (1988) Instrumental method of analysis, Wads worth Publishing Company.
- Kaushik N.K., Shukla S. K., (2023) Thermal Analysis Techniques and Applications, IK International Pvt. Ltd.
- Skoog D.A, (1997) Principle of Instrumental Analysis, Harcourt College Pub.
- Shah V., (2007) Handbook of Plastic Testing, Technology, Wiley-Inter science.
- Banwell C.N., McCash E.M., (2008) Fundamentals of Molecular Spectroscopy, Fourth Edition, Tata McGraw-Hill.
- Muhammad Malik, Jimmy Mays, Muhammad Raza Shah, (2021) Molecular Characterization of Polymers: A Fundamental Guide, Elsevier.

SUGGESTIVE READINGS

- Tanaka T., (1999) Experimental Methods in Polymer Sciences, Academic Press.
- Silverstein R.M., (1991) Spectrometric identification of organic compounds, John Wiley.
- Macomber R.S., (2008) A complete introduction to NMR spectroscopy, Wiley-inter science.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 15

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
POLYMERS IN PACKAGING	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry, Mathematics**	**-**

Learning objectives

- To learn about the Packaging systems and role of Polymer in packaging
- To acquire knowledge of various types of polymers as packaging materials

Learning outcomes

After studying this paper, students will be able to

- Apprehend the basic concept of packaging and its utilization for desired applications
- Assess the quality of packaging material and packaged product
- Select the packaging material and can design a packaged product

SYLLABUS OF DSC-15

THEORY COMPONENT-

UNIT-1: (10 Hours)

PACKAGING SYSTEMS

Types of packaging systems: box, bottle, tetrapack, pouch, shrink, vacuum packaging, controlled atmospheric packaging (CAP), modified atmospheric packaging (MAP), aseptic packaging.

UNIT 2: (10 Hours)

POLYMERS IN PACKAGING

Importance of polymers in packaging. Property requirements of Polymers for packaging applications: Structure and process requirements for the required Properties and applications. Properties and applications: PE (LLDPE, LDPE, HDPE, HMHDPE), PP, BOPP PVC, nylons, polyester, polycarbonate, PS, EPS, PVA, Ionomers & Fluoro polymers.

UNIT 3: (10 Hours)

TESTING OF POLYMER PACKAGING MATERIAL

Bursting strength, tensile strength, tear strength, puncture test, impact test (drop, falling dart), barrier properties test (water vapour, oxygen), sealing strength., migration & compatibility.

PRACTICAL COMPONENT (60 Hours)

- Preparation of packaging films (PP/ HDPE/ LDPE/ LLDPE/PVA)
- To prepare polyester film and find its WVTR.
- Identification of packaging materials with the help of FT-IR, DSC, TGA etc.
- Preparation of laminate films by various methods (heat, solvent, adhesives)
- Determination of physico-mechanical properties (density, bursting strength, tensile strength, tear strength, puncture strength, impact strength etc) of packaging materials.
- Determination of water vapor transmission rate of packaging material.
- To determine the seal strength of packaging materials.
- To determine compatibility of packaging film with the packaged material.
- Industrial visit of packaging industry/plant

ESSENTIAL/RECOMMENDED READINGS

- Robertson G.L., (2012) Food Packaging – Principles and Practice, CRC Press Taylor and Francis Group.
- Paine F.A., Paine H.Y., (1992) A Handbook of Food Packaging, Blackie Academic and Professional
- Sharma S., Aggarwal M., Sharma D., (2019), Food Frontiers, New Delhi Publisher
- N. C. Saha, M. Garg, S. Dey Sadhu, A. K. Ghosh(2022) Food Packaging-Materials, Techniques and Environmental Issues" by published by Springer.
- Garg, M., Meena, P.L., Sadhu, S.D., Alam, T. (2019). Food Packaging: A Practical Guide : Viba Press Pvt. Ltd.

SUGGESTIVE READINGS

- Coles R., McDowell D., Kirwan M.J., (2003) Food Packaging Technology, Blackwell.
- Sukhareva L.A., Yakolev V.S., Legonkova O.A., (2008) Polymers for packaging and containers in the food industry, VSP.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER –VI

POLYMER SCIENCE

Category I

(B.Sc. Honours in Polymer Science in four years)

DISCIPLINE SPECIFIC CORE COURSE – 16

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
POLYMER BLENDS AND COMPOSITES	4	2	0	2	Class 12th with Physics, Chemistry, Mathematics	-

Learning objectives

- To gain knowledge of polymer composites and its basic construction
- To learn about preparation, properties and characterization of polymer blends.

Learning outcomes

After studying this paper, students will be able to

- Understand various techniques for preparation of polymer blends
- Understand the types and forms of reinforcement materials used in composites
- Apply different production techniques for fabrication of polymer composites

SYLLABUS OF DSC-16

THEORY COMPONENT-

UNIT 1: (6 Lectures)

BASIC CONCEPT OF BLENDS

Definition of blends, types of blends (plastic-plastic, rubber-rubber and plastic-rubber blends), differences between: copolymer and IPNs, blends, alloys and composites; concept of miscibility, concept of free energy of mixing, phase equilibria, Flory-Huggins theory, spinodal, binodal and critical phase, Gibb's phase rule

UNIT 2: (6 Lectures)

PREPARATION AND PROPERTIES OF BLENDS

Methods of blending, compatibilizers, methods of compatibilization, factors affecting miscibility of polymer blends, effect of composition on properties (rheology, morphology, mechanical and thermal)

UNIT 3: (6 Lectures)

CHARACTERIZATION TECHNIQUES OF BLENDS

Applications of the following techniques: IR, microscopy (TEM, SEM and optical), TGA, DSC, DMA, viscosity, refractive index

UNIT 4: (6 Lectures)

POLYMER COMPOSITES

Definition; classification of composites; dispersed phase: (reinforcing fillers, non-reinforcing fillers), and (particulate matter, fibrous structure and platelet structures), continuous phase: thermoset matrix, thermoplastic matrix and high-performance resins, mechanism of reinforcement, various factors affecting reinforcements

UNIT 5: (6 Lectures)

DESIGN AND FABRICATION OF COMPOSITES

Fabrication techniques: Prepreg technology, injection and compression molding, vacuum bag molding, hand-lay-up process, spray-up technique, filament winding process, fibre placement process, Pultrusion, reaction transfer molding, laminating techniques, expansion processes, fabrication processes: adhesion, cohesion and mechanical processes & FRPs.

Design of a few polymer composite: basic design practice – material considerations, product considerations and design considerations, rule of mixture

PRACTICAL COMPONENT **(60 Lectures)**

- To prepare polymer blends by melt, solution and latex blending.
- To check the compatibility of blends by using microscope/DSC
- Determination of Lower and Upper Critical Solution Temperature of a polymer.
- To study the miscibility of the polymer blend using ultrasonic method.
- To study the miscibility of the polymer blend using viscosity method.
- To study the miscibility of the polymer blend using refractive index method.
- Determination of miscibility of polymer blends by density measurement method.
- Preparation of FRP laminates by hand lay-up technique.
- Evaluate the effect of filler loading on mechanical properties of a composite.
- Fabrication of composites by various techniques.
- Characterization (thermal and mechanical) of blends and composites.
- Determine the refractive indices of polymer blends by using abbe's refractometer.

ESSENTIAL/RECOMMENDED READINGS

- Paul D.R., Bucknall C.B., (2000) Polymer Blends Vol. 1 & Vol. 2, Wiley-Interscience.
- Robeson L.M., (2007) Polymer Blends, Hanser Gardner.
- Singh R.P., Das C.K., Mustafi S.K., (2002) Polymer Blends and Alloys, Asian Books Private Limited.

SUGGESTIVE READINGS

- Utracki L.A., (2003) Polymer Blends Handbook Vol. 1 & Vol. 2, Kluwer Academic Pub.
- Bhowmick A.K., De S.K., (1990) Thermoplastic Elastomers from Rubber-Plastic Blends, Ellis Horwood Publishers Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 17

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
POLYMERIC NANOMATERIALS AND NANOCOMPOSITES	**4**	**3**	**0**	**1**	**Class 12th with Physics, Chemistry, Mathematics**	**-**

Learning objectives

- To make students understand the basic concepts of nanomaterials and polymer nanocomposites.
- To learn the effect of shape, size, dispersion and percolation of nanomaterials on polymer nanocomposites
- To understand modification techniques of nanomaterials

Learning outcomes

After studying this paper, students will be able to

- Synthesize polymeric nanomaterials
- Demonstrate the knowledge of properties and structural aspects of polymeric nanomaterials
- Explore various areas of polymeric nanomaterial applications

SYLLABUS OF DSC-17

THEORY COMPONENT-

UNIT 1: **(9 Lectures)**

NANO-REINFORCING AGENTS

Preparation, structure and properties of nano-reinforcing agents: 1 D, 2 D and 3 D nanomaterials eg. nanoparticles, nanotubes, nano-clays, POSS, carbon nanostructures (CNTS, graphene)

UNIT 2: (21 Lectures)

PROPERTIES AND CHARACTERIZATION OF NANOMATERIALS

Morphology analysis of crystallites in nanocomposites: X-ray scattering & diffraction technique, Analysis of Nanostructure developed in semi-crystalline polymers during deformation, Nanostructure of two component amorphous block copolymers, effect of chain architecture. Factors governing properties of nanocomposites such as loading, dispersion and percolation, influence of size, shape and diameter of nanoparticles nanotubes, functionalization of nanomaterials

UNIT 3: (15 Lectures)

POLYMER NANOCOMPOSITES

Basic concepts, preparation, characterization and applications of polymer nanocomposites, technical challenges and understanding of interfacial dynamics using LJ potential and many body problems approach

PRACTICAL COMPONENT (30 Lectures)

- To analyze particle size of nanomaterials (nanoparticles).
- To prepare polymer nanocomposites by solution casting
- To prepare polymer nanocomposite by melt compounding.
- To determine the polymer nanocomposite by in-situ polymerization
- Determination of mechanical properties of nanocomposites.
- To prepare graphene oxide and its nanocomposite.
- Chemical modification of nanoclay and its characterization.
- Characterization (morphology and thermal) of nanocomposites by optical microscope, SEM, TEM, DSC, DMA, TG-DTA etc.
- Determination of electrical properties of nanocomposites.
- To prepare nano metal oxides and nano silica by chemical modification.

ESSENTIAL/RECOMMENDED READINGS

- Koo J.H., (2010) Polymer Nanocomposites, Tata McGraw-Hill.
- Bhattacharya S.N., (2008) Polymeric Nanocomposites-Theory and Practice, Hanser Gardner.
- Michler G.H., Balta F.J., (2005) Mechanical Properties of Polymer based on Nanostructure and Morphology, CRC Press.

SUGGESTIVE READINGS

- Tjong S.C., (2006) Nanocrystalline Materials, Elsevier Science.
- Owens F.J., Papoose C., (2003) Introduction to Nanotechnology, John-Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 18

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RUBBER TECHNOLOY	**4**	**2**	**0**	**2**	Class 12th with Physics, Chemistry, Mathematics	-

Learning objectives

- To learn about the concept of vulcanization and properties of rubbers

Learning outcomes

After studying this paper, students will be able to

- Apply the knowledge of preparation of rubbers and fibres
- Learn the knowledge of different types curing techniques

SYLLABUS OF DSC-18

THEORY COMPONENT-

UNIT 1: **(4 Lectures)**

RUBBERS: INTRODUCTION

Properties of rubber: Structure, glass transition temperature, mechanical properties (tensile, % elongation, compression set, fatigue resistance, resilience, hysteresis, hardness etc.)

UNIT 2: (10 Lectures)

PREPARATION, PROPERTIES AND APPLICATIONS

Natural rubber and synthetic rubbers (styrene-butadiene rubber, polybutadiene rubber, ethylene propylene diene rubber, butyl rubber, nitrile rubber, neoprene, silicone rubber, fluorocarbon rubber

Thermoplastic elastomers: Structure, properties, preparation, types and applications

UNIT 3: (6 Lectures)

MIXING OF RUBBERS

Need for compounding - Rubber mixing mechanism -mixing machinery- two roll mill-internal mixer–machine design -mixing in internal mixers &two roll mill, continuous mixers - mixing cycles and procedures, operating variables and mix quality

UNIT 4: (6 Lectures)

VULCANIZATION OF RUBBER

Theory and mechanism of sulphur and non-sulphur vulcanization (with and without accelerators), rheocurve of compounded rubber, pre and post vulcanization processes, properties of vulcanized rubber

UNIT 5: (4 Lectures)

VULCANISATION TECHNIQUES

Importance of vulcanization - vulcanization processes - batch processes - Continuous vulcanization – machinery & process - Reaction injection moulding of PU; silicone injection moulding.

PRACTICAL COMPONENT (60 Lectures)

- To determine tensile strength, modulus, elongation at break of Rubber sheet.
- To determine tear strength, abrasion resistance, heat build-up, resilience, hardness, flex resistance for rubber compounds.
- To determine curing time and physical properties of rubber compounds.

- To determine mooney viscosity of rubber using Mooney viscometer.

ESSENTIAL/RECOMMENDED READINGS

- Martin J.M., Smith W.K., (2007) Handbook of Rubber Technology, CBS Publisher.
- Mark J. E., Erman B., Eirich F.R., (2005) The Science and Technology of Rubber, Elsevier Academic Press.
- Blow S., (2000), HandBook of Rubber Technology, Hanser Gardner.

SUGGESTIVE READINGS

- Morton W.E., Hearle J.W.S., (2008) Physical Properties of Fibres, Woodhead Publishing.
- Blow.C.M. andHepburn.C. Rubber Technology and manufacture, Butterworths, 1982.
- Evans.C.W., Practical Rubber Compounding and processing, Applied Science Publishers, London, 1981.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

COMMON POOL OF DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE) COURSES OFFERED IN ODD SEMESTERS BY THE DEPARTMENTS

*{**Note1**: DSE Paper 1 to DSE: Paper 7 will be offered in odd semesters & DSE: Paper 8 to DSE: Paper 14 will be offered in even semesters.*

***Note 2**: Paper 15 is compulsory for all the students who want to pursue VII and VIII semesters. It will be offered in both VI and VII semesters.}*

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-1)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
ADVANCED ANALYTICAL TECHNIQUES FOR POLYMERS	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry**	**---**

Learning objectives

The Learning Objectives of this course are as follows:

- To acquaint the students with the advancements in different characterisation techniques (spectroscopy, microscopy and separation), their principle, instrumentation, and applications in characterization of polymeric materials.
- Students will be able to determine a chemical structure, purity, property and functionality in polymer samples.

Learning outcomes

After studying this paper, students will be able to

- Interpret NMR, raman, mass and IR–spectra for characterization of molecular structure of polymeric materials
- Elucidate the morphology, size, homogeneity and distribution of various polymers and polymeric samples

- Acquire the knowledge about separation process of components from polymer mixture and samples.

SYLLABUS OF DSE-1

THEORY COMPONENT-

UNIT 1 (14 Hours)

SPECTROSCOPIC TECHNIQUES

Principles, instrumentation, and applications for structural determination of polymers (functional group, tacticity, molecular structure, purity, unsaturation etc.) using FT-IR, electron spin resonance, Raman, nuclear magnetic resonance (^{13}C NMR).

Mass Spectroscopy: Introduction, basic principles, instrumentation, fragmentation patterns, and interpretation of mass spectra and applications. Basis and application of MALDI-TOF, and ESI-MS in characterisation of different polymers including biopolymer for determination of molecular mass and structures (branching, and chain length).

UNIT 2 (8 Hours)

CHROMATOGRAPHY TECHNIQUES

Introduction to chromatographic methods: thin layer chromatography, column and gas chromatography. Principles, instrumentation and application of Gas liquid Chromatography, High performance liquid chromatography and gel permeation chromatography (GPC) including brief about column, detectors and stationary phases and their significance.

UNIT 3 (8 Hours)

MICROSCOPIC AND MISCELLANEOUS TECHNIQUES

Optical microscopy, electron microscopy (SEM, TEM, AFM) and XPS, XRD: principle, instrumentation and applications (Particle size by Scherrer formula, d-Spacing, Crystal parameter, morphology etc.) for polymers characterization. Different methods used for determination of molecular mass, Particle size analyser, and measurement and importance of zeta potential.

PRACTICAL COMPONENT (60 Hours)

- To identify the functional groups and components in various polymers (homo and co polymers) using FTIR.
- To determination of Reactivity ratio by FTIR.
- To determination of purity of monomers by spectrophotometer
- To determine the cross linking density of a polymer samples by FTIR.
- To analyse the Raman spectra of given polymers(demonstrative).
- Evaluate percentage crystallinity and size of polymeric samples by XRD curve.
- To separate and identify additives in a given polymeric sample by thin layer chromatography.
- To separate and identify the polymeric samples and mixture by TLC.
- To analyze film morphology (homogeneity, distribution and size) by optical microscope.
- To determine the size of polymer/additives particles by particle size analyzer.
- Visit to an analytical laboratory and submit a report.

ESSENTIAL/RECOMMENDED READINGS

- Willard H.H., Merritt L.L., Dean J.A. (1988) Instrumental method of analysis, Wads worth Publishing Company.
- Skoog D.A, (1997) Principle of Instrumental Analysis, Harcourt College Pub.
- Shah V., (2007) Handbook of Plastic Testing, Technology, Wiley-Inter science.
- Banwell C.N., McCash E.M., (2008) Fundamentals of Molecular Spectroscopy, Fourth Edition, Tata McGraw-Hill.
- Maus, A. (2008). Characterization and Analysis of Polymers, Wiley and Sons.
- Malik, A. Mays, J. Shah, M. R. (2021) Molecular Characterization of Polymers: A Fundamental Guide, Elsevier.

SUGGESTIVE READINGS

- Tanaka T., (1999) Experimental Methods in Polymer Sciences, Academic Press.
- Silverstein R.M., (1991) Spectrometric identification of organic compounds, John Wiley.
- Macomber R.S., (2008) A complete introduction to NMR spectroscopy, Wiley-inter science.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-2)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical / Practice		
FIBRE MANUFACTURING TECHNOLOGY	4	2	0	2	Class 12th with Physics, Chemistry	---

Learning objectives

The Learning Objectives of this course are as follows:

- To learn about the basic concepts of spinning including melt and solution spinning.
- To understand various parameters affecting spinning, drawing and heat setting of fibre structure and properties

Learning outcomes

After studying this paper, students will be able to:

- Manufacture fibre with desired properties.
- Demonstrate the various spinning variables.

SYLLABUS OF DSE-2

THEORY COMPONENT-

UNIT 1 **(6 Hours)**

INTRODUCTION TO FIBRES

Manmade fibres: definition of man-made fibres, brief history of manmade fibres, relative merits and demerits of manmade and natural fibres

UNIT 2: **(12 Hours)**

MELT SPUN FIBRES

Melt spinning of PP, polyester and nylon-6 and nylon -66, Effect of parameters on structure development in nylon 6, PET, PP, post spinning operations (drawing, necking and heat setting), bulking/texturing

UNIT 3 (12 Hours)

SOLUTION SPUN FIBRES

Cellulose diacetate and triacetate fibres: Unit operations, dope preparation, dry-jet-wet-spinning

Acrylic fibres: Acrylonitrile polymerization (solution, emulsion and aqueous dispersion polymerization), Fibre manufacturing; polymer solubility and dope preparation, wet spinning (fibre extrusion and coagulation, structure of coagulated fibre, tow processing), dry-jet-wet-spinning

Rayon fibres: Viscose rayon process (chemistry and spinning), overview of alternatives to viscose process

Gel spinning of PE, PAN and PVA

PRACTICAL COMPONENT (60 Hours)

- To prepare polypropylene fibre by melt spinning.
- Study of preparation, melt spinning and properties of any one specialized melt spun fibre.
- Melt spinning and cold drawing of nylon 6 using laboratory spinning and drawing machines
- To prepare polyester fibre by melt spinning.
- Solution spinning of acrylic fibre.
- Dry-jet-wet spinning of PAN fibre.
- To characterize a woven fabric with respect to its dimensional properties: thread density, yarn number, yarn crimp, weave, cover factor, areal density, skewness, thickness
- To determine the crease recovery of fabric and observe the effect of loading time and recovery time on crease recovery.
- Drawing and heat setting of fibres.
- Chemical modification of fibres.
- Visit of Industry/R&D organization

ESSENTIAL/RECOMMENDED READINGS

- Gupta V.B., Kothari V.K., (1997) Manufactured Fibre Technology, 1st Ed Chapman and Hall.
- NPTEL course material on Manufactured fibre Technology.
- Macintyre J.E., (2005) Synthetic Fibres: Nylon, Polyester, Acrylic, Polyolefin, Elsevier Science.
- Vaidya A.A., (1988) Production of Synthetic Fibres, First Edition, Prentice Hall of India.

SUGGESTIVE READINGS

- Vaidya A.A., (1988) Production of Synthetic Fibres, First Edition, Prentice Hall of India.
- Kothari V.K., (2000), Textile Fibres: Developments and Innovations, IAFL Publications.
- Nakajima T., (2000) Advanced Fiber Spinning Technology, First Edition, Woodhead Publisher.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-3)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
TYRE TECHNOLOGY	4	2	0	2	Class 12th with Physics, Chemistry	---

Learning objectives

The Learning Objectives of this course are as follows:

- Familiarizing various types of tyres and their components.
- Developing the knowledge of manufacturing techniques of various tyres.

Learning outcomes

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

- Apply the knowledge of basic concept of manufacturing technology of tyre
- Demonstrate the designing and compounding of various tyre components.
- Evaluate performance and quality assessment of tyre.

SYLLABUS OF DSE-3

THEORY COMPONENT-

UNIT 1 **(8 Hours)**

INTRODUCTION AND TYRE MANUFACTURING

Classification: based on construction (pneumatic, radial, bias, cross ply, tube, tubeless, solid), Types of tyre on their uses: Cycle tyre, Car tyre, Light truck tyre, truck tyre, aeroplane tyre, earthmoving machinery tyre, Animal drone vehicles tyre etc. Tyre Components: Tread, sidewall, Bede, Apex, Solder, Inner Liner etc. Mixing (Mixing instruments: two roll mill, kneader, internal mixers), processing (extrusion, calendaring, bead winding), building drum, curing (molding machines etc.)

UNIT 2 **(12 Hours)**

TYRE DESIGN

Compound design (selection of chemical ingredients); process design (process parameters correlating with properties); product design (constructions), latest advances in materials and technologies

UNIT 3 **(10 Hours)**

TYRE TESTING

Endurance, groove crack test, plunger test, traction: dry, wet and snow, air permeation, noise test, rolling resistance, drivability, road test, wet braking test, fuel economy test, tread to ply pull out, bead seating test

PRACTICAL COMPONENT **(60 Hours)**

- To identify the type of rubber by reverse engineering.
- To prepare fabric- rubber coated ply.

- To test mechanical and physical properties of vulcanized rubber.
- To perform air aging properties of rubber and rubber to fabric ply.
- To determine bonding strength of rubber to fabric.
- To calculate abrasion losses of tyre tread.
- To calculate rebound resilience of a rubber.
- Tyre indexing and cut section analysis.
- To evaluate the compression set of a rubber.
- To determine rolling resistance test.
- Industrial Visit of Tyre Industry/ R&D

ESSENTIAL/RECOMMENDED READINGS

- Koutny F., Zling, (2007) Geometry and Mechanics of Pneumatic TIRE, CZE.
- French T., (1989) Tyre Technology, Adam Hilger, New York.
- Mark J.E., Erman B., Eirich F.R., (2005) The Science and Technology of Rubber, Elsevier.

SUGGESTIVE READINGS

- Ford T.L., Charles F.S., (1988) Heavy Duty Truck TIRE Engineering SAE's 34th L. Ray Buckingdale Lecture, SP729.
- Clark S.K., (1971) Mechanics of Pneumatic Tires, National Bureau of Standards, Monograph, US Govt. printing office.
- Gent A.N., Walter J.D., (2006) The Pneumatic TIRE, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-4)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
POLYMER PRODUCT DESIGN	4	2	0	2	Class 12th with Physics, Chemistry	---

Learning objectives

The Learning Objectives of this course are as follows:

- To understand physical properties of polymers required for product design
- To learn about plastic parts such as static and dynamic loaded parts for electrical, optical and mechanical applications (gears, bearings, pipes, seals, couplings and vibration dampers)

Learning outcomes

After studying this paper, students will be able to

- Explain the terminology involved in product design
- Distinguish the moulded hole, insert and undercut
- Describe the processing limitation of product design and stress analysis for product
- Demonstrate the plastic products for load bearing applications
- To do cost estimation of a polymeric product

SYLLABUS OF DSE-4

THEORY COMPONENT-

UNIT-1 (7 Hours)

INTRODUCTION TO PRODUCT DEVELOPMENT

Introduction, challenges in development process, distinguishing features in polymer products, polymer product classification, Selection of the right product, Generic development process, Criteria for a successful product process flow chart, identifying customer need and its analysis, Material data bank, comparative analysis, Criterion for material selection, types of polymers and their characteristics

UNIT 2 **(7 Hours)**

STRUCTURAL DESIGN AND DYNAMIC LOADING ON PLASTIC PARTS

Structure and physical properties of polymers, Dynamic load response of polymers, effects of cyclic loading, other forms of stress applied to polymer parts, design for stiffness, stress analysis of polymers, structural design

UNIT 3 **(10 Hours)**

DESIGN PROCEDURE FOR PLASTIC PARTS

Design procedure for plastic parts- Tolerance-Moulded holes-threads-radius- moulded hinges, integral hinge-snap fits Design of plastic structural parts for static loads, design of dynamically loaded plastic parts, design of plastic parts for electrical applications, design of plastic parts for optical applications.

UNIT 4 **(6 Hours)**

ESTIMATING, COSTING AND ELEMENTS OF COST

Cost estimation, importance of estimation, Costing, importance of costing, Difference between costing and estimation, Importance of realistic estimates, Estimation procedure, Elements of cost, Material Cost, Determination of Material cost, Labour cost, Determination of Labour Cost, Expenses , Cost of Product (Ladder of cost) , Illustrative examples.

PRACTICAL COMPONENT **(60 Hours)**

- Design requirement of Gear: materials, Bearings: Self lubricated plastic materials rubber bearing,
- Design of PVC piping: Raw materials, pipe design, specification and test procedure, manufacturing process
- Product, material, and Process requirement of Car bumper
- Application of reverse engineering in Rubber product design
- To prepare open and closed cell foam.
- To prepare rubber - metal composite products
- To determine mechanical properties of designed products

ESSENTIAL/RECOMMENDED READINGS

- Ulrich, T. K. T. and Eppinger, D.S. (2004), Product design and development, Tata McGraw-Hill, 3rd edition.
- Mahajan, M. (2008) Industrial Engineering and Production Management, Dhanpat Rai Publication.
- Mollay, A.R. (1994) Plastic Part Design for Injection Moulding, Hanser Publishers, Munich Vienna, New York.

SUGGESTIVE READINGS

- Hollins, B. Pugh, S. (1990) Successful product design, Butterworth & Co.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-5)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
POLYMERS IN BIOMEDICAL APPLICATIONS	4	2	0	2	Class 12th with Physics, Chemistry	---

Learning objectives

The Learning Objectives of this course are as follows:

- To acquire knowledge of biocompatibility and biodegradation
- To learn about applications and testing of bio-compatible polymer in tissue engineering

Learning outcomes

After studying this paper, students will be able to

- Explain the basic concepts and requirement of biomedical applications and biocompatibility
- Apply the knowledge of various polymers in biomedical application

SYLLABUS OF DSE-5

THEORY COMPONENT-

UNIT 1 **(8 Hours)**

BASICS OF BIOMATERIALS

Important features for Biomedical Application: responsiveness, estimations of biodegradation and biocompatibility.

Types of Polymers in Biomedical applications and their Importance, hydrogel, fibres, bio-ceramics, bio-elastomers and membrane

UNIT 2 **(10 Hours)**

POLYMERS IN BIOMEDICAL APPLICATION

Permanent implants for function-orthopaedics (Internal and External artificial organ), cardio vascular, respiratory patches and tubes, digestive system, genitourinary system, nervous system, orbital (corneal and lens prosthesis)–permanent implant for cosmoses, other applications of engineered material in clinical practices, silicone implants. polymer membranes, polymer skin, polymeric blood

UNIT 3 **(12 Hours)**

MISCELLANEOUS APPLICATIONS (DENTAL, LENSES, DRUG DELIVERY AND TISSUE ENGINEERING)

Contact Lenses, Hard Lenses, Gas Permeable Lenses, Flexible Lenses, Soft Lenses, Hydrogels, Equilibrium Swelling, Absorption And Desorption, Oxygen Permeability, Types of Soft Lenses, Manufacture, Cleaning And Disinfection.

Dental applications, denture bases, crown and bridge resins, plastic teeth, mouth protectors, maxillofacial prosthetic materials, restorative material, polyelectrolyte based restoratives, sealants, adhesives, dental impression and duplicating materials, agar, algmater elastomers.

Introduction to drug delivery, polymers in controlled drug delivery, dressing strips, polymer drug vessels, core shell and nanogels, tissue engineering, uses of cellulose, chitosan and alginate

PRACTICAL COMPONENT **(60 Hours)**

- Evaluate the biocompatibility of polymeric samples.
- Determination of the degradation behavior of polymers such as thermal, hydrolytic etc.
- Preparation of membranes and measurement of their absorption behavior.
- Preparation and characterization of dental cement.
- Prepare a hydrogel and characterization.

- Prepare jaw by powdered silicone rubber
- To find out biocompatibility of polymer products by enigmatic test
- Determination of mechanical strength of polymers.
- To find out hydro degradation of artificial bone.
- To prepare porous membranes.

ESSENTIAL/RECOMMENDED READINGS

- Park, J. B. (2003) Bio-materials, An Introduction, CRC Press.
- Tiwari A., Tiwari A., (2013) Nanomaterials in drug delivery, Imaging and Tissue Engineering, Wiley.
- Pilla S., (2011) Handbook of Bioplastics and Biocomposites Engineering Applications, Wiley.

SUGGESTIVE READINGS

- Ratner B.D., Hoffman A.S., (1996) An Introduction to Materials in Medicine, Academic Press.
- Saltzman W.M., (2001) Drug delivery: Engineering principles for drug therapy, Oxford University Press.
- Kalia S., Averous L., (2011) Biopolymers: Biomedical and Environmental Applications, John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-6)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
CONDUCTING POLYMERS	4	2	0	2	Class 12th with Physics, Chemistry	---

Learning objectives

The Learning Objectives of this course are as follows:

- To impart knowledge of structure and electrical properties of conducting polymers.
- To learn about applications of conducting polymers.

Learning outcomes

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

- Perform the synthesis and doping in conducting polymers.
- Analyze and demonstrate the properties of conducting polymers

SYLLABUS OF DSE-6

THEORY COMPONENT-

UNIT 1 **(8 Hours)**

BASIC ASPECTS OF CONDUCTING POLYMERS

Historical background, band structure, band alignment, conduction mechanism, theory of electrical conduction in conducting polymers

UNIT 2 **(10 Hours)**

SYNTHESIS OF CONDUCTING POLYMERS

Chemical, electrochemical and mechanical synthesis of polyaniline, polypyrrole, polythiophene. Doping and its effects on properties of conducting polymers

UNIT 3 (12 Hours)

PROPERTIES & APPLICATIONS OF CONDUCTING POLYMERS

Electrical properties, resistance, impedance, capacitance, magnetic properties and optical properties of different conducting polymers. Applications of conducting polymers in electronic devices, sensors, rechargeable batteries, solar cells, light emitting devices, biomedical devices, organ transplant, artificial mussels and EMI shielding etc.

PRACTICAL COMPONENT (60 Hours)

- Synthesis of polyaniline, polypyrrole and polythiophene by chemical polymerizations.
- Synthesis of conducting polymers by electro chemical polymerizations.
- To improve electrical conductivity of PANI by chemical doping.
- Evaluation of mechanical properties of conducting polymer films/sheets.
- Determination of the thermal properties of conducting polymers.
- To prepare a molded sheet of conducting polymers.
- To manufacture molded conducting device
- To study the effect of doping of Polypyrrole
- To measure the electrical conductivity and resistivity of conducting polymer films/sheets.
- To design and demonstrate the conducting polymer based devices i.e light emitting devices, chemical sensor and solar cell.

ESSENTIAL/RECOMMENDED READINGS

- Chandrasekhar P., (1999) Conducting Polymers, fundamentals and applications: A practical approach, Springer.
- Nalwa H.S., (1997) Handbook of Organic Conductive Molecules and Polymers: Conductive polymers: synthesis and electrical properties, Vol. 2, Wiley.
- Skotheim T.A., Elsenbaumer R.L., Reynolds J.R., (2007) Handbook of Conducting Polymers, CRC Press.
- Batrinescu, G., Constantin, L. A., Cuciureanu, A., & Constantin, M. A. (2016). Conductive polymer-based membranes. Conducting Polymers.
- Fernandez O.T., (2015) Conducting Polymers, Royal Society of Chemistry.

- Almeida L.C., (2013) Conducting Polymers: Synthesis, Properties & Applications, Nova Publishers.
- Gupta, R. K. (Ed.). (2022). Conducting Polymers: Chemistries, Properties and Biomedical Applications. CRC Press.

SUGGESTIVE READINGS

- Dyson, R. W., (1982) Speciality polymers Chapman and Hall publications.
- Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
- Sołoducho, J., & Cabaj, J. (2016). Conducting polymers in sensor design. Conducting Polymers. Rijeka: Intech, 27-48.
- Otero, T. F. (2016). Conducting Polymers: Bioinspired Intelligent Materials and Devices. Royal Society of Chemistry.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-7)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical / Practice		
BIO-BASED AND BIODEGRADABLE POLYMERS	4	2	0	2	Class 12th with Physics, Chemistry	---

Learning objectives

The Learning Objectives of this course are as follows:

- To gain knowledge of biopolymers and their isolations
- To acquire knowledge on structure and properties of biopolymers
- To understand the basic applications of various biopolymers

Learning outcomes

After studying this paper, students will be able to:

- Explain the applications of bio-based and biodegradable polymers
- Distinguish and analyse biopolymers
- Evaluate the strength and properties of polymers

SYLLABUS OF DSE-7

THEORY COMPONENT-

UNIT 1 (12 Hours)

BASICS TO BIOPOLYMERS & NATURAL MACROMOLECULES

Introduction to the concept of Bio Based Polymers and Biodegradable Polymer. Significance, classifications, properties and applications of biopolymers and natural polymers such as Starch, cellulose, chitosan, gelatine, protein, fatty acids, lipids, aliphatic polyesters (PLA, PHB), cellulose

UNIT 2 (8 Hours)

PROCESSING

Isolation, processing of biopolymers: composite formation, blending and solvent casting

UNIT 3 (10 Hours)

APPLICATIONS

Applications of biopolymers in packaging, biomedical testing and devices, agriculture: soil conditioning and micro-nutrient delivery

PRACTICAL COMPONENT (60 Hours)

- To determine the molecular weight of biopolymers.
- Isolation of starch from wheat/rice/potato
- Isolation of gelatin from natural resources.
- To prepare Poly(lactic acid).
- To prepare a chitosan based composite for biomedical applications.
- To prepare blends of natural polymers and find out miscibility
- Develop a biodegradable film by solution casting of biopolymers.
- Estimate the biodegradability by soil burial test.
- Evaluate swelling index, porosity, hardness of a film.
- Estimate the water vapor transmission rate of a biopolymeric film.

ESSENTIAL/RECOMMENDED READINGS

- Byrom D., (1991) Biomaterials: Novel Materials from Biological Sources, First Edition, Macmillan Publishers Ltd.
- Bastioli C., (1987) HandBook of Biodegradable polymers, Rapra Technology.
- Niaounakis M., (2015) Biopolymers: Processing and Products, First Edition, Elsevier Inc.

SUGGESTIVE READINGS

- Johnson R.M., Mwaikambo L.Y., Tucker N., (2003) Biopolymers, Rapra Technology.
- Pilla S., (2011) Hand Book of Bioplastics & Biocomposites for Engineering Applications, Wiley.
- Alexander S., (2003) Biopolymers, Vol. 1, Wiley.

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DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-8)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
ENGINEERING DRAWING & MOLD DESIGN	4	3	0	1	Class 12th with Physics, Chemistry	---

Learning objectives

- To understand the various planes of work pieces
- To learn about the various mold and their components
- To acquaint with the concepts of mold & die design and their key features

Learning outcomes

The Learning Objectives of this course are as follows:

After studying this paper, students will be able to

- Explain about the graphics design
- Apply design features in structure of injection molds
- Apply design features in structure of extrusion dies

SYLLABUS OF DSE-8

THEORY COMPONENT-

UNIT 1 (18 Hours)

INTRODUCTION & PROJECTIONS OF PLANES, POLYHEDRA SOLIDS AND SOLIDS OF REVOLUTION

Introduction of Drawing instruments, sheet layouts lines, lettering and Dimensioning scales, various types of projections, First and Third angle systems of orthographic projections. Projection of Points in different quadrants: parallel to one reference plane, inclined to one plane but perpendicular to the other, inclined to both reference planes. Projections of Polyhedra Solids and Solids of Revolution – in simple positions with axis perpendicular to a plane, with axis parallel to both planes, with axis parallel to one plane and inclined to the other, Projections of sections of Prisms, Pyramids, Cylinders and Cones.

UNIT 2: **(12 Hours)**

MOLD DESIGNING AND MAKING

Materials selection for mold and die, mold making processes: casting, electro deposition, cold hobbing, pressure casting, spark machining. Tool room machines and their application: CNC machines-CNC EDM-CNC, Milling- CNC. Basis structure and feed system of mould: core, cavity, runner, gates, bolster, and cooling unit.

UNIT 3: **(15 Hours)**

EJECTION SYSTEM & UNDER CUTS

Ejector grid, ejector plate assembly, ejection techniques, ejection from fixed half and sprue pullers, Form pin, split cores, side cores, stripping internal undercuts, molds for threaded components. Daylight molds–general, undercut, formin, double & triple daylight mold

PRACTICAL COMPONENT **(30 Hours)**

- Lines, lettering & Dimension (Sketch Book): Scale-representative Fraction, Plan scale, Diagonal Scale, Vernier scales (In sheet), comparative Scale, & scale of chords (Sketch Book)
- Geometric conception, caners used in drawing practice. Conic Section: Construction of Ellipse, Parabola & Hyperbola by different methods (In sheet)
- Construction of cycloid, Epicycloids, Hypocycloid and Involutes (In sheet) Archimedean and Logarithmic spiral, (Sketch book)
- Type Projection, Orthographic Projection: First Angle and third Angle Projection (Sketch Book)
- Projection of Straight lines, different position of straight lines, methods for determining True length, true inclinations and Traces of straight lines (Four problems in sheet and three problems in Sketch Book)
- Projection of Planes: Different positions of Plane lamina like.: - Regular polygon, circle three of planes (Four problems in Drawing sheet and three problems in Sketch Book).
- Demonstration software used in mold and die design (Auto CAD, solid works, etc.)

- To design and validate well labelled mold from clay/POP/resin and prepare plastic products.
- Demonstration of Lathe, milling, CNC and wire cutting machine
- Tool room/industrial visit

ESSENTIAL/RECOMMENDED READINGS

- Engineering Drawing, Basant Agarwal & CM Agrawal, Tata McGraw Hill.
- Engineering Drawing Geometrical Drawing, P.S. Gill, S.K. Katara & Sons.
- Engineering Drawing, Dhanarajay A Jolhe, Tata McGraw Hill.
- Pye R.G.W., (2000) Injection mould design, Affiliated East West Press Pvt. Ltd.
- Strong A.B., (2005) Plastics: Materials & Processing, Prentice Hall.
- Rosato D.V., Rosato D.V., (2000) Injection Moulding Handbook, CBS Publisher.

SUGGESTIVE READINGS

- Engineering Drawing, N.D. Bhatt, Charotar Publishing House Pvt. Ltd.
- Morton-Jones D.H., (2007) Polymer Processing, Chapman & Hall.
- Crawford R.J., (1998) Plastic Engg, Butterworth-Heinemann.
- Rees H., (1995) Mould Engineering, Hanser Publisher.

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DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-9)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
POLYMER PHYSICS	4	2	0	2	Class 12th with Physics, Chemistry	---

Learning objectives

- To learn about the conformations of polymer chains.
- To understand the morphology of crystalline and amorphous polymers.

Learning outcomes

After studying this paper, students will be able to

- Apply concepts of polymer physics.
- Classify polymers on the basis of physical properties.
- Determine crystal structure of polymers.

SYLLABUS OF DSE-9

THEORY COMPONENT-

UNIT 1 (12 Hours)

FUNDAMENTALS OF POLYMER PHYSICS

Potential energy and conformational energy of molecules, conformations and configurations, tacticity, isomeric states and isomerism in polymers, stereoisomerism, geometric isomerism, Random coils and average end to end distance, more realistic chains, excluded-volume effect, chain flexibility and the persistence length.

UNIT 2 (10 Hours)

REGULAR CHAINS AND CRYSTALLINITY

Regular and irregular chains, Polymers with 'automatic' regularity, Polydienes, Helical molecules, Determination of crystal structures by X-ray diffraction, Crystal structures of some common polymers (PE, PP, PET, Nylons, PVC)

UNIT 3 (8 Hours)

MORPHOLOGY AND MOTION

Introduction, degree of crystallinity, Experimental determination of crystallinity. Crystallites: fringed-micelle model, Chain-folded crystallites, Extended-chain crystallites, Non-crystalline regions and polymer macro-conformations:, Lamellar stacks, Spherulites and other polycrystalline structures, Concept of chain orientation, orientation in amorphous and crystalline polymers, Uniaxial and biaxial orientation practical significance, Optical microscopy of spherulites, Light scattering by spherulites.

PRACTICAL COMPONENT (60 Hours)

- To determine density of fibres by Density Gradient Column.
- To develop and study the growth of PP spherulites in different crystallization conditions.
- To study the morphology of the given fibre sample by Infrared spectroscopy.
- Interpretation crystallization and isothermal crystallization of polymers by DSC thermogram
- To determine crystallinity and orientation in polymers by XRD
- To determine the d-spacing in a given polymer sample by XRD.
- Morphological study of polymers by optical microscopy and interpretation of optical micrograph.
- Interpretation of molecular weight distribution curve/chromatogram
- To study Tyndall effect in polymer solution.
- To study the effect of crystallinity on mechanical properties of fibres.
- R&D Lab Visits

ESSENTIAL/RECOMMENDED READINGS

- Sperling L.H., (1993) Introduction to Physical Polymer Sciences, J. Wiley N.Y.
- Crompton R.T., (1989) Molecular Motions in High Polymers, Pergamon Press N.Y.
- Hiemenz, P. C., & Lodge, T. P. (2007). Polymer chemistry. CRC press.

SUGGESTIVE READINGS

- Crompton T.R., (1989) Analysis of Polymers, Pergamon Press N.Y.
- Ward I.M., (1979)Mechanical Properties Of High Polymers, John Wiley.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-10)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
MATERIAL SCIENCE	4	3	0	1	Class 12th with Physics, Chemistry	---

Learning objectives

- To introduce the fundamentals of material science especially dielectric materials, semiconducting materials and nanomaterials
- To impart knowledge of different types of materials, their properties and applications

Learning outcomes

After studying this paper, students will be able to

- Explain the structure, function, properties of various materials
- Apply the knowledge of smart materials for desired applications

SYLLABUS OF DSE-10

THEORY COMPONENT-

UNIT 1: (15 Hours)

BASICS OF MATERIALS STRUCTURE

Amorphous and crystalline structure, unit cells and space lattices, X-ray diffraction of crystal structures, miller indices of planes and directions, packing geometry in metallic, covalent and ionic solids, single and polycrystalline materials, imperfections in crystalline solids magnetism, intrinsic and extrinsic semiconductors, dielectric properties, absorption and transmission of electromagnetic radiation.

UNIT 2: (15 Hours)

ADVANCED MATERIALS

Ferroelectric, piezoelectric, optoelectronic, semiconducting behaviour, lasers and optical fibres, photoconductivity and superconductivity, nanomaterials (synthesis, properties and applications), biomaterials, shape memory alloys, Ceramics: structure, properties, processing and applications of traditional and advanced ceramics.

UNIT 3: (15 Hours)

METALS AND ALLOYS

Solid solutions, solubility limit, intermediate phases, intermetallic compounds, iron-iron carbide phase diagram, heat treatment of steels, cold, hot working of metals, recovery, recrystallization and grain growth. Microstructure, properties and applications of ferrous, non-ferrous alloys and polymer alloy

PRACTICAL COMPONENT (30 Hours)

- To check the hardness of composite materials by rockwell hardness tester.
- To determine % composition of metals, fillers etc.
- Thermogravimetric analysis of different Polymers (Using TGA)
- Determination of degradation profile and filler content of a polymer (using TGA).
- Study of mechanical stress v/s strain behavior of a polymer (tensile and flexural)
- Determination of impact strength of a polymer by izod method.
- Determination of impact strength of a polymer by charpy method.
- To determine magnetic properties of materials.
- To determine mechanical properties (strength, modulus) of materials.
- Preparation of advanced polymer composite material for different applications (packaging and biomedical).
- To prepare safety glass and evaluate its properties.

ESSENTIAL/RECOMMENDED READINGS

- Shackelford J.F., (2010) Materials Science And Engineering Handbook, Third Edition CRC Press.
- Mittemeijer E.J., (2011) Fundamentals of Materials Science: The Microstructure–Property Relationship Using Metals as Model Systems, Springer.
- Sedha R.S., Khurmi R.S., (2004) Materials Science, S. Chand.

SUGGESTIVE READINGS

- Kakani S.L., Kakani A., (2006) Material Science, New Age International.
- Yao J., Zhou Z., Zhou H., (2019) Highway Engineering Composite Material and its Application, Springer.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-11)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
SMART MATERIALS	4	3	0	1	Class 12th with Physics, Chemistry	---

Learning objectives

- Overview of smart materials, Piezoelectric Ceramics, Piezo-polymers, Magnetostrictive Materials, Electroactive Polymers, Shape Memory polymers.
- To learn the fundamentals of electro and magneto rheological fluids, thermally responsive polymers, modelling of smart materials, introduction to composite smart materials and smart hydrogels.

Learning outcomes

After studying this paper, students will be able to

- Explain polymer based smart materials
- Demonstrate applications of smart materials.

SYLLABUS OF DSE-11

THEORY COMPONENT-

UNIT 1: **(15 Hours)**

INTRODUCTION

Smart materials and structures: components and classification of smart structures, single crystals vs polycrystalline systems, common smart materials and associated stimulus-response, application areas of smart systems, piezoelectric materials- piezoelectric effect, parameter definitions, piezoceramics, piezopolymers, piezoelectric materials as sensors, actuators and bimorphs.

UNIT 2: (15 Hours)

SMART POLYMERS

Thermally responsive polymers, electroactive polymers microgels (synthesis, properties and applications), protein-based smart polymers, ph-responsive and photo-responsive polymers, self-assembly, molecular imprinting using smart polymers, approaches to molecular imprinting, drug delivery using smart polymers

UNIT 3: (15 Hours)

SMART HYDROGELS

Synthesis, fast responsive hydrogels, molecular recognition, smart hydrogels as actuators, controlled drug release, artificial muscles, hydrogels in microfluidics. smart systems for space applications: elastic memory composites, smart corrosion protection coatings, self-healing materials, sensors, actuators, transducers, deployment devices, molecular machines.

PRACTICAL COMPONENT (30 Hours)

- To determine the elastic properties of polymers.
- To determine % swelling of a hydrogel.
- To determine the sensing power of a sensor.
- To prepare corrosion resistance coatings.
- To test the corrosion inhibition of materials.
- To prepare electroactive microgel.
- To prepare polymer for artificial muscles and study its behaviour with pH change.
- To determine the flexural strength of epoxy/ polyester composite.
- To synthesise and test water absorption behaviour of hydrogel.
- To prepare a polymer based photo sensor.

ESSENTIAL/RECOMMENDED READINGS

- Leo D.J., (2007) Engineering Analysis of Smart Material Systems, Wiley.
- Addington M., Schodek D.L., (2005) Smart Materials and New Technologies in Architecture, Elsevier.
- Otsuka K., Wayman (Eds.) C.M., (1998) Shape Memory Materials, Cambridge University Press.
- Gandhi, M.V., Thompson B. S., (1992) Smart Materials and Structures, Chapman & Hall.
- Schwartz, M., (2006) New Materials, Processes, and Methods Technology, CRC Press.

SUGGESTIVE READINGS

- Ball, P., (1997) Made to Measure: Materials for the 21st Century, Princeton University Press.
- Galaev, I., Mattiasson, B., (Eds.), (2008) Smart Polymers: Applications in Biotechnology and Biomedicine, 2nd ed, CRC Press.
- Yui, N., Mrsny, R. J., Park, hK., (Eds.), (2004) Reflexive Polymers and Hydrogels: Understanding and Designing Fast Responsive Polymeric Systems, CRC Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-12)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
AUTOMOBILE APPLICATIONS OF POLYMERS	4	3	0	1	Class 12th with Physics, Chemistry	---

Learning objectives

- To know various sources of materials used in automobiles.

- To learn about polymeric materials significance in automobiles structural and mechanical components.
- To study about rubber components used in automobiles.

Learning outcomes

After completing this course, the students

- Explain the knowledge about requirements of automobile industry.
- Apply the polymeric (plastic) components in automobile interior and exterior parts.
- Determine the rubber components used in automobile parts.

SYLLABUS OF DSE-12

THEORY COMPONENT-

UNIT 1: (8 Hours)

INTRODUCTION TO AUTOMOTIVE COMPONENTS AND MATERIALS

History of automobile industry, need for polymers, advantages and limitations of polymers, competition between plastics, composites and other materials, processing, designing with plastics, selection criteria of material.

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UNIT 2: (10 Hours)

POLYMERS IN THE INTERIOR OF THE VEHICLE

Interiors, dominance of polymeric components, Fashion and function, Plastics surfaces (Texture and fogging), Plastic structure and panel application (Sandwich concept, Instrumental panel, other sensitive panels), Structural and mechanical components (Seating, Door and window furniture, steering wheel, airbags, seat belts, pedals, instrumental and others).

UNIT 3: (10 Hours)

POLYMERS IN THE EXTERIOR OF THE VEHICLE

Exteriors: Body panels and structure – Painting problems – Bumpers – Other exteriors: Grills, Spoilers, Mirrors, Door handles, Wheel trim, Road wheels, Sun roof components, Windscreen wiper assemblies.

UNIT 4: (10 Hours)

ENGINE, POWERTRAIN AND CHASSIS

The engine compartment, cooling system, under bonnet structure, transmission, engine hang on parts, engine interior, composite engine, suspension, steering, brakes, fuel tanks, electrics: battery boxes, circuitry, lighting and instrumentation, electronics.

UNIT 5: (7 Hours)

RUBBER PRODUCTS

Rubber mounts, spring, seals, O-ring, rubber to metal bonding components, coupling hoses, brake lining, disc brakes.

PRACTICAL COMPONENT (30 Hours)

- To prepare EPDM profile for windshield and door seal.
- To prepare bumper material and test its impact strength.
- To prepare O'Rings/gaskets material for sealing applications
- To manufacture automobile carpet/leather and test its mechanical and physical properties.
- To prepare laminated material for radiator pipe
- To manufacture carbon fibre-epoxy composite for high strength applications
- To prepare plastic joint and test its strength.
- To find out scratch resistance of a coated automobile part.
- To prepare composite for railway breaker
- To analyze flexural strength of jumping rod.
- Industrial Visit

ESSENTIAL/RECOMMENDED READINGS

- Maxwell, J,. (1994) “Plastics in the Automotive Industry”, SAE internationals, Woodhead Publication, England.
- Mann, D., (1999) “Automotive Plastics and Composites Worldwide Markets and Trends” to 2007, 2nd Edition , Elsevier advanced technology.
- Ashby, M. F., Shercliff, H., Cubon, D., (2007) “Materials Engineering Science, Processing and Design”, Butterworth Publications.
- Brian, C., Patrick, G., and Colin J., (2007) Automotive Engineering: Light Weight, Functional and Novel Materials, Taylor & Francis.

- Groover, M. P., (2005) Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 2nd edition, John Wiley & Sons.
- Stauber, R., Vollrath, L. (2007) Plastics in Automotive Engineering: Exterior Applications, Hanser publications.
- Marur, S., (2011) Plastics Application Technology for Safe and Lightweight Automobiles.

SUGGESTIVE READINGS

- Callister, W. D., (2005) Materials Science and Engineering an Introduction, 6th edition, John Wiley & Sons.
- Yamagata, H., (2005) The Science and Technology of Materials in Automotive Engines, Yamaha Motor Co. Ltd., Japan Woodhead Publishing Limited.
- Davies, G., (2003) Materials for Automobile Bodies, Butterworth-Heinemann Publications.
- Koronis, G. Silva, A., (2018) Green Composites for Automotive Applications, Woodhead Publishing Series in Composites Science and Engineering.
- Sehanobish, K., (2009)"Engineering Plastics and Plastic composites in Automotive Applications", SAE internationals, Warrendale.

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DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-13)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
POLYMERS IN ENERGY APPLICATION	4	2	0	2	Class 12th with Physics, Chemistry	---

Learning objectives

The Learning Objectives of this course are to:

- Make students familiar with use of advanced polymers for energy applications
- Learn about the manufacturing of fuel cells

- Understand polymer properties related to energy components

Learning outcomes

After studying this paper, students will be able to

- Select the polymers for energy applications
- Explain working process of lithium ion batteries and fuel cell

SYLLABUS OF DSE-13

THEORY COMPONENT-

UNIT 1: **(6 Hours)**

INTRODUCTION

Importance and need of energy storage, modes of energy transmission, batteries, thermal, mechanical storage, hydrogen, pumped hydropower, flywheels, role of polymer in energy storage applications. environmental and sustainability issues.

UNIT 2: **(8 Hours)**

ENERGY STORAGE DEVICES BASED ON POLYMERS

Introduction, principal, methodology & working: photovoltaics, supercapacitors, lithium-ion batteries: PVAc based polymer blend electrolytes for lithium batteries, preparation of solid polymer electrolytes based batteries, perovskite-type composite polymer electrolytes, PPO-type composite polymer electrolytes, sulfide-type polymer electrolytes, solid polymer electrolytes with ionic liquid, solid polymer electrolytes with cellulose.

UNIT 3: **(8 Hours)**

FUEL CELLS

Hydrogen generation & storage, fuel cells, principles and nanomaterials design for; proton exchange membrane fuel cells (PEMFC), sulfonated poly (ether-ether ketone)s, sulfonated poly(aryl ether) for PEMFC and direct methanol fuel cell (DMFCs). Polymer composite membrane role (cation/anion/proton-exchange membranes) in bio-electrochemical systems – construction and performance of MFCs.

UNIT 3: **(8 Hours)**

POLYMER NANOCOMPOSITES FOR RENEWABLE ENERGY STORAGE SYSTEMS

Solar cells: Types, functioning, mechanism, materials for solar cell and structure design, Concept of solar cells with organic quantum dots, Quantum dots (polymer multiple & molecular multiple quantum dots), polymer-inorganic hybrid solar cells, hybrid conjugated polymer-inorganic semiconductor composites, semiconducting polymer-based bulk heterojunction solar cells, current trends and future status.

PRACTICAL COMPONENT (60 Hours)

- To prepare methanol fuel cell.
- To design low, medium and high-temperature fuel cell.
- Preparation of proton exchange by membrane fuel cell.
- Preparation of hydrogen fuel cell.
- To prepare quantum dots grown by molecular layer deposition for photovoltaics.
- Synthesis of polymer multiple quantum dots.
- To test the efficiency of solar cell.
- Demonstrate the working principle of solar cell.
- To prepare PVAc based polymer blend electrolytes.
- To test the energy storage of Lithium batteries.

ESSENTIAL/RECOMMENDED READINGS

- Deborah, D.L., Chung, (2002) “Composite Materials”, Springer.
- Sun, S. S., Sariciftci, N. S., (2005) “Organic Photovoltaics”, CRC press-Taylor & Francis.
- Mohammad, F., (2007) “Specialty Polymers: Materials and Applications”, I. K. International Pvt Ltd.
- Chanda, M. Roy, S. K., (2008) “Industrial Polymers, Specialty Polymers“, and Their Applications, CRC Press.
- Ram K. Gupta, R. K., (2022) “Conducting Polymers for Advanced Energy Applications”, CRC Press.
- Thangadurai, T. D., Nandhakumar, M., Thomas, S., Nzihou, A., (2022) “Polymer Nanocomposites for Energy Applications”, Wiley.

SUGGESTIVE READINGS

- Malaika, S. Al, Wilkie, C. A., Golovoy, A., (2001) “Specialty Polymer Additives”, Wiley.
- Dyson, R. W., (1982) “Speciality polymers”, Chapman and Hall publications.

- Ise, N., Tabushi, I., (1983) "An Introduction to Speciality Polymers", CUP Archive.
- Inamuddin, Ahamed M. I., Boddula, R., Altalhi, T., (2022) "Polymers in Energy Conversion and Storage".
- Kroschwitz, J. I. (2003) "Encyclopedia of polymer science and technology", John Wiley.
- Mark, H. F. (2013). "Encyclopedia of polymer science and technology", John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-14)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
3D PRINTING OF POLYMERS	4	3	0	1	Class 12th with Physics, Chemistry	---

Learning objectives

- Impart students to the fundamentals of various 3D Printing techniques for application to various industrial needs.
- Students will be able to convert part files into STL format and will understand the method of manufacturing of liquid based, powder based and solid based techniques.

Learning outcomes

The Learning Objectives of this course are as follows:

After studying this paper, students will be able to

- Use software tools for 3D printing
- Prepare 3D printed modules
- Construct products using LOM and FDM technologies

SYLLABUS OF DSE-14

THEORY COMPONENT-

UNIT 1: (15 Hours)

BASICS OF 3D PRINTING TECHNOLOGIES

Introduction to 3D printing, advantages. commonly used terms, process chain, 3D modeling, classification of 3D printing process (comparing different 3D printing technologies, including FDM, SLA, SLS, and MJ.), applications to various fields.

UNIT 2: (15 Hours)

MATERIALS FOR 3D PRINTING

Comparing the different material types available for 3D Printing product, including PLA, ABS, PETG, TPE, nylon, PC, as well as 8 exotic filaments that are not focussed on physical properties.

UNIT 3: (15 Hours)

3D PRINTING TECHNOLOGY

Laminated object manufacturing (LOM): Models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

Fused deposition modelling (FDM): Models and specifications, process, working principle, applications, advantages and disadvantages, case studies, practical demonstration

PRACTICAL COMPONENT (30 Hours)

- Manufacturing of additives by selective laser Sintering (SLS)
- To prepare fibre by FDM
- Manufacturing of Polyamide products by powder bed fusion
- Product manufacturing by extrusion 3D printing process (fusion, deposition, modelling)
- Direct ink writing of 3D functional materials
- To manufacture polymer products by Multi jet fusion
- To prepare photoreactive polymeric materials by material jetting.
- To prepare the shoe sole by 3D printing.
- To prepare filament by FFF (fused filament fabrication)
- Preparation the elastomeric thread by 3 D printing technology

ESSENTIAL/RECOMMENDED READINGS

- Chua C.K., Leong K.F. and LIM C.S, (2010) Rapid prototyping: Principles and Applications, World Scientific publications, 3rd Ed.

- Pham, D.T. and Dimov, S.S. , (2001) Rapid Manufacturing, Springer.
- Wohlers, T., (2000) Wohlers Report 2000, Wohlers Associates, 2000

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SUGGESTIVE READINGS

- Jacobs, P. F., (1996) " Rapid Prototyping and Manufacturing"–, ASME Press.
- Gibson, I., Rosen D., Stucker B., 2014) Additive Manufacturing Technologies, Springer, 2nd Ed.

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DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-15)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
RESEARCH METHODOLOGY IN POLYMER SCIENCE	4	3	0	1	Class 12th with Physics, Chemistry	---

Learning objectives

- To understand some basic concepts of research and its methodologies
- To learn research problem and parameters
- To learn about preparation a project proposal
- To study components of research paper, report and thesis

Learning outcomes

After studying this paper, students will be able to

- Select a particular research method.
- Apply research skills in qualitative and quantitative data analysis and presentation.
- Write the research paper, project and thesis with advanced critical thinking skills.

SYLLABUS OF DSE-15

THEORY COMPONENT

UNIT 1: (10 Hours)

RESEARCH METHODS

Identification and selection of the research problem, Literature survey for required information, Search engines (Scopus, Science direct, Web of science, Google scholar) for scientific information, Encyclopaedia, Reference books, abstraction of a research paper – drawing inferences from data, - qualitative and quantitative analysis, Reference, Management Software like Zotero/Mendeley, Software for paper writing and formatting like chem draw, origin, LaTeX and MS Office. Developing a research plan, Format of research proposal: individual research proposal and institutional proposal.

UNIT 2: (10 Hours)

Research TOOLS, Paper and report writing

Correct usage of technical language and scientific peer network, ethics with respect to science and research, intellectual honesty and research integrity, scientific misconduct: falsification, fabrication and plagiarism (FFP), redundant publications: duplicate and overlapping publication, salami slicing, selective reporting and misrepresentation of data. Thesis and Paper writing, General format, page and chapter formation. Analysis and presentation of data, Statistical test: choosing and using suitable statistical tests. The use of quotation - footnotes - tables and figures - referencing - appendices - revising the paper or thesis - editing and evaluating and the final product - proof reading - the final types copy.

Thesis and Paper writing: Format of thesis- title, abstract, introduction, objectives, methods, results, tables, figures, graphs, discussion, summary, acknowledgement, in-text citations, reference list, and appendix. Presentation skill, them of conferences and workshops - Oral presentation skills – Post presentation of research outcome, Abstracts, Proceedings of technical deliberation - Publication in journals, conference proceedings and in book or as book chapters.

Research article & Research Proposals

Components of research article - Title, abstract, key words, introduction, citations, introduction, objectives, methods, results, tables figures, graphs, discussion summary, and references. Instruction to authors by journal for writing a research paper. Components of proposal document- Title, aim, research background, project outline, research methodology & budgeting, time schedule, deliverables and references.

UNIT 3: (15 Hours)

PUBLICATION ETHICS

Publication ethics: definition, introduction and importance, Best practices / standard setting initiatives and guidelines COPE (Committee on publication ethics), conflicts of interest, publication misconduct: definition, concept, problems that lead to unethical, behaviour and vice-versa, types, violation of publication ethics, authorship and contributor ship, identification of publication misconduct, complaints and appeals, predatory publishers and journals. Software for detection of Plagiarism determining the mode of action, literature survey, mode of approach of actual investigation.

PRACTICAL COMPONENT (30 Hours)

- Literature survey (scopus, sciencedirect, elsevier, scifinder etc.)
- Report writing
- Reference writing using softwares like Endnote, Mendley etc.
- Drawing of chemical structures using software like chem draw etc.
- Poster making
- Paper writing
- Graphical representation using excel, origin etc.

ESSENTIAL/RECOMMENDED READINGS

- Kothari, C. K. Garg, G.(2018) Research Methodology: Methods and Techniques, New Age International, 4th Edition,
- Rajaraman V., (2008) Computer Oriented Numerical Methods, Prentice Hall of India.
- Jain M. K., Iyengar S. R. K. and Jain R.K., (2007) Numerical Methods for Scientific and Engineering Computation, New Age International.

SUGGESTIVE READINGS

- Bhattacharya D. K., (2009) Research Methodology, Excel Books India.
- Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., (2002) An introduction to Research Methodology, RBSA Publishers.
- Kothari, C.R., (1990) Research Methodology: Methods and Techniques. New Age International. 418p.
- Sinha, S.C. and Dhiman, A.K., (2002). Research Methodology, Ess Ess Publications. 2 volumes.
- Trochim, W.M.K., (2005). Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
- Wadehra, B.L., (2000). Law relating to patents, trade marks, copyright designs and geographical indications. Universal Law Publishing.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY THE DEPARTMENTS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
BASICS OF POLYMER SCIENCE	4	2	0	2	Class 12th with Physics, Chemistry	---

Learning objectives

The Learning Objectives of this course are as follows:

- To familiarize with the structure of polymers will be introduced to students.
- To acquaint students with knowledge of molecular weight determination and polymer solubility

Learning outcomes

After studying this paper, students will be able to

- Distinguish crystalline and amorphous states of polymers
- Correlate polymer flexibility with the glass transition temperature
- Illustrate structure-property relationship of polymers
- Apply mathematical formulae to depict polymer solution properties

SYLLABUS OF GE-1

THEORY COMPONENT-

UNIT – I **(10 Hours)**

Introduction and classification of polymers, configuration and conformation of polymers, nature of molecular interaction in polymers, entanglement, various structures of copolymers such as linear branched and cross-linked copolymers, Polymer solutions, solubility parameter, solution viscosity, polymer solubility, thermodynamics of polymer solutions

UNIT – 2 **(10 Hours)**

Physical properties, stress–strain behaviour, mechanical properties (tensile, flexural, impact, fatigue, hardness, creep, abrasion), introduction to flow & glass transition temperature (T_g) and its measurement of T_g, factors affecting the glass transition temperature

UNIT – 3 **(10 Hours)**

Nature and structure of polymers – structure-property relationships, Molecular weight of polymers (Mn, Mw etc.), polydispersity, molecular weight distribution and determination of molecular weight by viscosity, end group analysis, cryoscopy, ebulliometry, light scattering & ultracentrifugation methods

PRACTICAL COMPONENT **(60 Hours)**

- Chemical identification of polymers: Functional groups (associated with polymers).
- Determination of molecular weight by solution viscosity/end group analysis.
- To check the solubility of the given polymeric sample in different solvents.
- To determine the melting point of crystalline polymers.
- Determination of heat deflection temperature & vicat softening point of polymers.
- Determination of Acid value of acrylic acid
- Estimation of hydroxyl value by PVA and Cyclohexanol
- Determination of epoxy equivalent weight of the epoxy resin.
- Determination of saponification value of oil.
- Study of three component systems.

ESSENTIAL/RECOMMENDED READINGS

- Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
- Ghosh P., (2010) Polymer Science and Technology: Plastics, Rubbers, Blends and Composites Tata McGraw-Hill.
- Gowarikar V.R., (2019) Polymer Science, New Age International Publishers Ltd, 3rd Edition
- Billmeyer F.W., (2007) Textbook of Polymer Science, Wiley, India.
- Shah V., (1998) Handbook of Plastics Testing Technology, Wiley interscience publications.

SUGGESTIVE READINGS

- Schultz J.M., (2001) Polymer Crystallization, American Chemical Society.
- Seymour R.B., Carraher C.E., (2000) Polymer Chemistry, Marcel Dekker.

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GENERIC ELECTIVES (GE-2)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
ADVANCED ANALYTICAL TECHNIQUES	4	2	0	2	Class 12th with Physics, Chemistry	---

Learning objectives

The Learning Objectives of this course are as follows:

- To acquaint the students with the advanced instrumental techniques and their applications in characterization of polymeric materials.

Learning outcomes

After studying this paper, students will be able to

- Elucidate surface morphology of polymeric materials
- Determine crystallinity of various polymers and their characterization on the basis of their thermal stability and glass transition temperature

SYLLABUS OF GE-2

THEORY COMPONENT-

UNIT – I **(8 Hours)**

Basic principle of spectroscopy, molecular and atomic spectra, Lambert-Beer's law, Frank-condon principle, electromagnetic radiation and it's properties, interaction of radiation with matter, statistical method of analysis

UNIT – 2 **(8 Hours)**

Principles and applications in structural determination of polymers (functional group, tacticity, molecular structure, purity, unsaturation etc.): Infra-red spectroscopy, UV-Vis spectroscopy, electron spin resonance, raman, nuclear magnetic resonance spectrometer

UNIT – 3 **(8 Hours)**

Thin layer chromatography, high performance liquid chromatography, gel permeation chromatography (GPC), gas chromatography.

UNIT – 4 **(6 Hours)**

Optical microscopy, electron microscopy (SEM, TEM, AFM) and XRD: basics and applications (size, morphology, crystallinity etc.) in polymers characterization

PRACTICAL COMPONENT (60 Hours)

- Study of UV stabilization of polymer samples by UV-visible spectrophotometer.
- Calculate weight percentage of inorganic and organic ingredients in polymeric compounds.
- Determination of K-value of PVC.
- Quantitative determination of impurities by UV-Vis. spectrophotometer.
- Characterization of Filler Content /Ash Content of common polymers by Thermogravimetric Analysis, (TGA).
- Identification of additives in a processed polymer by chromatography.
- Interpretation of FTIR, NMR and Raman spectra of polymers.

ESSENTIAL/RECOMMENDED READINGS

- Willard H.H., Merritt L.L., Dean J.A. (1988) Instrumental method of analysis, Wads worth Publishing Company.
- Skoog D.A, (1997) Principle of Instrumental Analysis, Harcourt College Pub.
- Shah V., (2007) Handbook of Plastic Testing, Technology, Wiley-Inter science.

- Banwell C.N., McCash E.M., (2008) Fundamentals of Molecular Spectroscopy, Fourth Edition, Tata McGraw-Hill.

SUGGESTIVE READINGS

- Tanaka T., (1999) Experimental Methods in Polymer Sciences, Academic Press.
- Silverstein R.M., (1991) Spectrometric identification of organic compounds, John Wiley.
- Macomber R.S., (2008) A complete introduction to NMR spectroscopy, Wiley-inter science.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-3)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
POLYMER AND ENVIRONMET	4	2	0	2	Class 12th with Physics, Chemistry	----

Learning objectives

The Learning Objectives of this course are as follows:

- To give understanding of basics of care to be taken while handling polymer products.
- To know the Safety and hazardous of their manufacturing processes.
- To impart Knowledge of the subject will help students to see the environmental impact of plastic and resin.
- To understand the current benefits and concerns surrounding the use of plastics and look to future priorities, challenges and opportunities.

Learning outcomes

After studying this paper, students will be able to

- Explain the basics of environmental and safety issues in the chemical industry.
- Apply the safety in handling monomer and resins

- Demonstrate the final product of polymer in environment after use and its waste management

SYLLABUS OF GE-3

THEORY COMPONENT-

UNIT – 1 **(10 Hours)**

Health and safety, Plastics in the society, Plastics in the environment, Plastic waste management, Plastic waste in the marine and terrestrial environment, Plastic material degradation, regulations for hazardous chemicals in articles/plastic products, coated articles. Separation techniques of plastic wastes (density, float sink and froth floatation methods, optical, spectroscopic, sorting by melting temperature etc.).

UNIT – 2 **(10 Hours)**

Thermoplastic waste management: 4 R's approach (reduce, reuse, recycle (mechanical and chemical), recover), recycling classification- - primary - secondary - tertiary - quaternary recycling with examples.

UNIT – 3 **(10 Hours)**

Disposal processes and Various waste treatment methods – controlled tipping, pulverization, compositing, Energy from waste – (incinerators- pyrolysis, factors affecting incineration), new developments in thermal disposal of refuse, on-site disposal methods, compacting and baling. Recycling of Polyolefins, PVC, PET, Polystyrene, Polyamides (Nylon-6 and Nylon-6,6). Recycling of Thermosets –reclaiming of rubber –pyrolysis, depolymerization of scrap rubber, tyre retreading, uses of recycled rubber.

PRACTICAL COMPONENT **(60 Hours)**

- Primary recycling of plastic waste collected from the environment.
- Secondary recycling of MSW by incorporating and blending the recyclable waste with virgin polymers.
- To study composting of natural/biopolymers.
- Separation of polymer mixture by sink flotation technique.
- Separation of polymer mixture by selective dissolution technique.

- Recovery of BHET from PET by chemical recycling process
- Recovery of Adipic Acid from Nylon 66 by chemical recycling technique
- To study the effect of vulcanized rubber at varying ratio (in powder form) on mechanical properties of rubber vulcanizate
- Preparation of plasticizer from polyester waste.
- Preparation of reclaim from tyre waste.

ESSENTIAL/RECOMMENDED READINGS

- Chandra, R., & Adab, A. (1994). Rubber & Plastic Waste: Recycling, Reuse and Future Demand. CBD Publishers.
- Scheirs, J., & Long, T. E. (Eds.). (2005). Modern polyesters: chemistry and technology of polyesters and copolyesters. John Wiley & Sons.

SUGGESTIVE READINGS

- Blow, S. (1998). Handbook of Rubber Technology.
- Brandrup, J., Bittner, M., Michaeli, W., & Menges, G. (1996). Recycling and Recovery of Plastics, Hanser. Gardner, München.
- Goodship, V. (2007). Introduction to plastics recycling. iSmithers Rapra Publishing.
- Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
- Ehrenstein G.W., Riedel G., Trawiel P., (2004) Thermal analysis of plastics, Hanser.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-4)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
BIOMEDICAL APPLICATIONS OF POLYMERS	4	2	0	2	Class 12th with Physics, Chemistry	----

Learning objectives

- To acquire knowledge of biopolymer and biodegradation
- To gain knowledge of applications and testing of biopolymers

Learning outcomes

After studying this paper, students will be able to

- Explain basic concepts and requirement of biomaterials and biocompatibility
- Apply the knowledge of various biomaterials for a desired bio-application

SYLLABUS OF GE-2

THEORY COMPONENT-

UNIT – 1 **(6 Hours)**

BASICS OF BIOMATERIALS

Concept of biocompatibility and biodegradability, responsiveness, estimations of degradation and biocompatibility, Important biomaterials: hydrogel, fibres, bio-ceramics, bio-elastomers and membranes

UNIT – 2 **(8 Hours)**

POLYMERS AS BIOMATERIALS

Polyester and polysaccharides, natural gums, biodegradable polymers, polymers and hydrogels

UNIT – 3 **(8 Hours)**

BIOMATERIALS FOR ORGAN TRANSPLANTS AND TISSUE ENGINEERING

Properties and applications of polymers for organ transplant e.g. dental cement, orthopaedic, skin, artificial kidney etc., basic concepts of tissue engineering, important polymers for tissue engineering: cellulose, chitosan and alginates

UNIT – 4 **(8 Hours)**

DRUG DELIVERY AND WOUND CARE

Introduction to drug delivery, polymers in controlled drug delivery, dressing strips, polymer drug vessels, core shell and nanogels, polymers for antimicrobial activity, bio-conjugates

PRACTICAL COMPONENT (60 Hours)

- Evaluate the biocompatibility of polymeric samples.
- Determination of the degradation behavior of polymers such as thermal, hydrolytic degradation etc.
- Preparation of membranes and measurement of absorption behavior.
- Preparation and characterization of dental cement.
- Preparation of a hydrogel and its characterization.
- Determination of tensile strength of biopolymers.
- Determine the swelling rate of biopolymers
- Preparation of nanogel and find its water absorption
- preparation and characterization of membrane for skin transplant

ESSENTIAL/RECOMMENDED READINGS

- Tiwari A., Tiwari A., (2013) Nanomaterials in drug delivery, Imaging and Tissue Engineering, Wiley.
- Pilla S., (2011) Handbook of Bioplastics and Biocomposites Engineering Applications, Wiley.
- Ratner, Buddy D., Allan S. Hoffman, Frederick J. Schoen, and Jack E. Lemons. "Biomaterials science: an introduction to materials in medicine." San Diego, California (2004): 162-4.
- Park, J. B., & Bronzino, J. D. (2002). Biomaterials: principles and applications. crc press.

SUGGESTIVE READINGS

- Ratner D., Hoffman A.S., (1996) An Introduction to Materials in Medicine, Academic Press.
- Saltzman W.M., (2001) Drug delivery–Engineering principles for drug therapy, Oxford University Press.
- Kalia S., Averous L., (2011) Biopolymers: Biomedical and Environmental Applications, John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-5)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
POLYMERS FOR PACKAGING	4	2	0	2	Class 12th with Physics, Chemistry	----

Learning objectives

- To learn about the basic necessities and importance of packaging
- To acquire knowledge of various types of packaging materials

Learning outcomes

After studying this paper, students will be able to

- Apply the basic concepts of packaging and its utilization for desired applications
- Evaluate the quality of packaging material and packaged product

SYLLABUS OF GE-5

THEORY COMPONENT-

UNIT – 1 **(6 Hours)**

PACKAGING SYSTEMS

Types of packaging systems: box, bottle, tetra, pouch, shrink, vacuum, gas, controlled atmosphere packaging (CAP), modified atmosphere packaging (MAP), and aseptic packaging

UNIT – 2 **(8 Hours)**

POLYMERS IN PACKAGING

Properties and applications: LLDPE, LDPE, HDPE, HMHDPE, PP, PVC, nylons, polyester, polycarbonate, PS, EPS, PLA, PVA and Starch

UNIT – 3 **(8 Hours)**

PACKAGING PROCESS TECHNIQUES

Preparation of packaging materials by thermoforming, co-extrusion, extrusion-stretch blow molding, injection molding, BOPP films

UNIT – 4 **(8 Hours)**

TESTING OF POLYMER PACKAGING MATERIAL

Bursting strength, tensile strength, tear strength, puncture test, impact test (Drop, falling dart), permeability test (water vapour, oxygen), biodegradability, sealing strength

PRACTICAL COMPONENT **(60 Hours)**

- To identify packaging materials with the help of FT-IR, DSC, TGA etc.
- Determination of physico-mechanical properties (density, burst strength, tensile strength, tear strength, puncture test strength, impact strength etc).
- Determination of water vapor transmission rate of packaging material.
- To test sealing strength integrity of packaging materials.
- To check biodegradability of packaging material.
- Preparation biodegradable packaging film
- Determination of water vapor transmission rate of packaging material.
- To test seal strength integrity of packaging materials.
- To check biodegradability of packaging material.
- To determine compatibility of film.

ESSENTIAL/RECOMMENDED READINGS

- Robertson G.L., (2005) Food Packaging Principles and Practice, CRC press.
- Paine F.A. and Paine H.Y., (1992) A Handbook of Food Packaging, Blackie Academic and Professional.
- Sharma S., Aggarwal M., Sharma D., (2019), Food Frontiers, New Delhi Publisher
- N. C. Saha, M. Garg, S. Dey Sadhu, A. K. Ghosh(2022) Food Packaging-Materials, Techniques and Environmental Issues" by published by Springer.
- Garg, M., Meena, P.L., Sadhu, S.D., Alam, T. (2019). Food Packaging: A Practical Guide : Viba Press Pvt. Ltd.

SUGGESTIVE READINGS

- Robertson G.L., (2012) Food Packaging–Principles and Practice, CRC Press.

- Coles R, McDowell D., Kirwan M.J., (2003) Food Packaging Technology, Blackwell.
- Sukhareva L.A., Yakolev V.S., Legonkova O.A., (2008) Polymers for packaging materials for preservation of foodstuffs, VSP.

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GENERIC ELECTIVES (GE-6)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
POLYMERS FOR ELECTRICAL AND ELECTRONIC APPLICATIONS	4	2	0	2	Class 12th with Physics, Chemistry	----

Learning objectives

- To learn about basic concepts of polymer electrical and electronic properties
- To gain knowledge of electrical and electronics applications of polymers

Learning outcomes

After studying this paper, students will be able to

- Synthesize a conducting polymer for a specific application
- Apply the knowledge of properties of polymers required for electrical and electronics applications

SYLLABUS OF GE-6

THEORY COMPONENT-

UNIT – 1 **(6 Hours)**

INTRODUCTION TO POLYMERS

Petro polymers, conducting polymers, biopolymers, composites, Band diagram, processing of polymers, doping (chemical and ion), advantages and disadvantages of conducting polymers, limitations

UNIT – 2 **(8 Hours)**

PREPARATION OF CONDUCTING POLYMERS

Synthetic methods: chemical, electrochemical, photochemical etc. (polyaniline, polypyrrole, polythiophene, polyacetylene, etc.), methods to enhance the processability of conducting polymers

UNIT – 3 **(8 Hours)**

PROPERTIES

Dielectric strength, dielectric loss, charge storage capacity, electrical conductivity, heat capacity, magnetism, hysteresis loop, shape memory, mechanical properties, EMI shielding

UNIT – 4 **(8 Hours)**

ELECTRONIC APPLICATIONS

Semiconducting organic materials, polymer based electronic devices, organic field effect transistor, organic transistors, plastic solar cell, light emitting diode, supercapacitor, sensors etc.

PRACTICAL COMPONENT **(60 Hours)**

- Preparation of conducting polyaniline and measurement of their conductivity.
- Preparation of polypyrrole and measurement of their conductivity.
- Preparation of polythiophene and measurement of their surface resistivity.
- Preparation and testing of conducting polymers for sensor applications.
- Measurement of multilayer insulation of a thin film.
- Measurement of dielectric strength of a polymer film.
- Measurement of mechanical properties of insulating cable
- Preparation polymer sample and analyzed its dielectric strength
- Preparation of a conducting polymer nanocomposites.
- Preparation polymeric semiconductor

ESSENTIAL/RECOMMENDED READINGS

- Skotheim T.A., Elsenbaumer R.L., Reynolds J.R., (1998) Handbook of conducting polymers, Vol. 1 and Vol. 2, Marcel Dekker.
- Nalwa H.S., (1977) Organic Conductive Molecules and Polymers, John Wiley & Sons.
- Bredas J.L., Silbey R., (1991) Conjugated Polymers: The Novel Science and Technology of Highly Conducting and Nonlinear Optically Active Materials, Kluwer Academic Publishers.
- Bikales M., Menges O.B., (1986) Encyclopedia of Polymer science and Engineering, Second Edition, Vol.5, John Wiley & Sons.

SUGGESTIVE READINGS

- Lyons M.E.O., (1994) Electroactive polymers, Plenum Press.
- Margolis J., (1993) Conducting Polymers and Plastics, Chapman & Hall.

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