



Banasthali Vidyapith

**Details of Courses Related to Environment and
Sustainability**

Environment Studies

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
2	0	0	2

Learning Outcomes:

After the completion of this course, students will be able to:

- Describe the interaction of organisms with their environment.
- Describe concepts and methods from ecological and environmental sciences and their application in understanding the environmental issues.
- Appreciate the ethical, cross-cultural, and historical context of environmental issues and the links between human and natural systems.
- Reflect critically about their roles and identities as citizens, consumers and environmental actors in a complex, interconnected world.

Note : The paper will contain Eight questions in all. Candidates are required to attempt any five.

Course Content:

- Introduction to Environmental Science and Ecosystem: Definition, scope and importance Concept of Ecosystem, Structure of Ecosystem (Biotic and Abiotic factors).
- Dynamics of Ecosystem: Food Chain, Food web and Ecological Pyramids. Brief idea of energy flow. Salient features of forest, grassland, Desert and Aquatic ecosystem.
- Natural Resources and their conservation: Renewable and non-renewable resources. Uses and over utilization/exploitation of Natural resources: Forest, Water, Mineral, Food, Energy and Land.
- Water conservation and management: Rain water harvesting. Elementary idea of solid waste management.
- Biodiversity and its conservation: Definition, Types and Importance of Biodiversity. Endangered and Endemic Species of India. Bio-geographical classification. Hot spots and India as a Mega diversity nation. Threats to Biodiversity: Habitat loss, poaching of wild life.
- Conservation of Biodiversity: Brief idea of *in-situ* and *ex-situ* conservation of Biodiversity.
- Environmental Pollution: Definition, Causes, Effects of air, water, soil, noise, thermal and nuclear pollution. Control and preventive measures of air, water, soil, noise, thermal and nuclear pollution.
- Global problems: Climate change, global warming, Ozone layer depletion, Acid Rain and Photochemical Smog. Elementary knowledge of Natural Disaster Management.
- Human Population, Social Issues and Environment: Population growth, Variation, Explosion and Sex ratio. Environment and Public Health (HIV/AIDS). Environmental Ethics (Issues and Possible Solution).
- Environmental legislation and Environmental Protection Acts: Air, Water, Wildlife Forest acts. Role of information technology in Environment and Human Health.

Recommended Books:

1. Basu, M. & Xavier Savarimuthu, S. J. (2017). *Fundamentals of Environmental Studies*.(1st ed.). Delhi, India: Cambridge University Press.
2. Bharucha, E. (2005). *Textbook of Environmental Studies for Undergraduate Courses* Hyderabad, India: Universities Press
3. Rajagopalan, R. (2015), *Environmental Studies from Crisis to Cure*, (3rd ed.). Delhi, India: Oxford University Press.
4. Rana, S.V.S. (2004). *Environmental Studies*. Meerut, India: Rastogi.

5. Sharma, J.P. (2017). *Environmental Studies* (4th Ed.). Delhi, India: University Science Press.

Suggested e-learning materials:

1. Environmental Studies:

<https://swayam.gov.in/course/141-environmental-studies-i>

<https://www.ugc.ac.in/oldpdf/modelcurriculum/env.pdf>

Water and Sustainable Development

Max. Marks : 100

(ESA: 100)

L	T	P	C
0	0	0	2

Learning Outcomes:

After the completion of this course, students should be able to:

- Classify major causes of exploitation of water resources, particularly in the Indian and Asian context.
- Summarize rainwater harvesting and water conservation measures.
- Describe methods of Irrigation management.
- Describe importance of Wetlands and its conservation

Course Content:

Water and sustainable development. Water and human health – Access to safe drinking water and sanitation; public health issues. Water and food production – Role of irrigation in food security. Shifts in cropping patterns, Rain-fed agriculture, increasing use of groundwater. Environmental, economic and social implications of exploitation of ground water resources. Water and human amenities – Urban water supplies; exploitation, conservation and rainwater harvesting. Wetland, its use and abuse with Ramsar Convention. Urban floods, storm water drainage and integrated urban water management (IUWM). Irrigation management – canals and micro-irrigation.

Recommended Books :

1. Asawa, G. L. (2005). *Irrigation and Water Resources Engineering*, New Delhi, India: New Age.
2. Biswas, A. K., Jellau, M., & Stout, G. (1993). *Water for sustainable development in 21st century – A Global perspective*, Oxford, UK: Oxford University Press.
3. David, L. F. (2007). *Water Policy for Sustainable Development*. Baltimore, Maryland: Johns Hopkins University Press.
4. Jain, S. K., & Singh, V. P. (2003). *Water Resources Systems Planning and Management*. Amsterdam, Netherlands: Elsevier.

Suggested e-learning materials:

1. Water, Society and Sustainability
https://onlinecourses.nptel.ac.in/noc18_hs36/preview
2. Irrigation Efficiencies - II and Irrigation Methods and their Suitability
<https://nptel.ac.in/courses/105102159/15>

Water Pollution Monitoring, Control Technology and Management

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

After the completion of this course, students will be able to:

- Describe water pollution and water resource management
- Describe waste water sampling method
- Illustrate characterization of waste water.
- Distinguish primary, secondary and tertiary waste water treatment methods.

Course Content:

Section A

Water pollution- Causes and Pollutants, Categories of waste water, generation of waste water, Water resource management.

Section B

Waste water sampling and monitoring, Methods of analysis, determination of organic matter, inorganic substances, Physical characteristics of bacterial measurements.

Section C

Waste water treatment, Basic processes of primary treatments; Pretreatment, sedimentation and floatation.

Secondary treatments; Activated sludge process, Trickling filter, sludge treatment and disposal.

Advanced waste water treatment, N-removal, P-removal, Advanced Biological Systems, Chemical oxidation, Removal of suspended solids, Dissolved solids.

Recommended Books:

1. Bartram, J., & Balance, R. (2007). *Water Quality Monitoring. A practical guide to the design and implementation of freshwater quality studies and monitoring programmes*. London, UK: Chapman & Hall.
2. Burke, G., Singh, B. R., & Theodore, L. (2000). *Handbook of Environmental Management and Technology*(2nded.).New York, NY: John Wiley & Sons.
3. Eilbeck, W. J. & Mattock, G. (1987). *Chemical Processes in Waste Water Treatment*.Chichester, UK:Ellis Horwood Limited.
4. Gray, N. F. (1990). *Activated Sludge, Theory and Practice*. Oxford, UK:Oxford University Press.
5. Helmer, R., & Hespanhol, I. (1997).*Water Pollution Control - A Guide to the Use of Water Quality Management Principles*.UNEP. Suffolk, Great Britain: St Edmundsbury Press.
6. Kostas, V., & Dimitra, V. (2012). *Water Quality Monitoring and Assessment*.Rijeka, Croatia:InTechOpen.
7. Loucks, D. P., &Beek, E. V. (2005).*Water Resources Systems Planning and Management An Introduction to Methods, Models and Applications, Studies and Reports in Hydrology*. UNESCO.
8. UNEP, (2008). *Water Quality for Ecosystem and Human Health*(2nd ed.). Ontario, Canada: UNEP
9. UNICEF, (2008). *Handbook on Water Quality*.New York. NY: Children's Fund UNICEF.

Suggested e-learning materials:

1. Wastewater Management
<https://nptel.ac.in/courses/105105048/>
2. Water and Waste Water Engineering
<https://nptel.ac.in/courses/105104102/>
3. Industrial Waste Water Engineering
<https://nptel.ac.in/courses/105106119/36>
4. Waste water sampling procedure
http://www.epa.ie/licences/lic_eDMS/090151b28036bb01.pdf
5. Waste water Nutrient Removal
https://www.des.nh.gov/organization/divisions/water/wmb/rivers/watershed_conference/documents/2009_fri_infastructure_3.pdf

Natural Hazards and Disasters

Max. Marks : 100

L	T	P	C
0	0	0	2

(ESA: 100)

Learning Outcomes:

After the completion of this course, students should be able to:

- Explain the key concepts, definitions, perspectives of all hazards and management.
- Describe prevention and mitigation of natural hazards.
- Depict the preparedness response and recovery management of natural disasters.
- Elucidate the sustainable development methods in disaster mitigation.

Course Content:

Introduction to Disasters and Hazards, Processes (Internal and External), Types of Hazards: causes and consequences, Prediction and Indicators of Natural Disasters, Socio-economic and Health impacts of Natural Disasters.

Natural Disasters – Earthquake: Processes, Magnitude, Intensity and Impact. Volcanism: Types, Risks and Impact. Tsunami and Cyclone: Types, Causes, processes and Impact. Floods: Introduction, Magnitude, Frequency, Zonation and Impact. Mass Wasting: Classification, causes and Impact. Disaster Management: Prevention, Preparedness and Mitigation, Planning and control of Natural Disaster. Case Studies: Nepal Earthquake, Kedarnath Disaster, Bhuj Earthquake 2001.

Recommended Books :

1. Bolt, B. A. (1988). *Earthquakes*. New York, NY: WH Freeman & Company.
2. Decker, R. W. & Decker, B. B. (2005). *Volcanoes* (4th ed.). New York, NY: WH Freeman & Company.
3. Dowrick, D. (2003). *Earthquake Risk Reduction Zone*. England, UK: John Wiley & Sons.
4. Gere, J. M., & Shah, H. C. (1984). *Terra Non Firme Understanding and Preparing for Earthquakes*. New York, NY: WH Freeman & Company.
5. IGNOU (2005). *Understanding Natural Disasters*. eGyanKosh, Noida, India: Shagun Offset Press.
6. Keller, E. A., & Devecchio, E. D. (2015). *Natural Hazards* (4th ed.). New York, NY: Pearson.
7. Keller, E.A. (1978). *Environmental Geology* (9th ed.). North Carolina, NC : Bell & Howell.
8. Montgomery, C.W. (2013). *Environmental Geology* (10th ed.). New York, NY : Mc-Graw-Hill.
9. Prakash, I. (1994). *Disaster Management*. Ghaziabad, India: Rastriya Prahari.
10. Sharma, V. K. (1995). *Disaster Management*. New Delhi, India: Indian Institute of Public Administration (IIPA).
11. Singh, S. (2015). *Environmental Geography*. Allahabad, India: Pravalika.

Suggested e-learning materials:

1. Introduction to Natural hazards

<https://epgp.inflibnet.ac.in/ahl.php?csrno=17>

https://onlinecourses.nptel.ac.in/noc19_ce14/preview

2. Disasters and Hazards

<https://ndma.gov.in/en/>

Climate change and Environment

Max. Marks : 100

(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

After the completion of this course, students will be able to:

- Describe the concept of climate change.
- Identify the indicators of climate change and explain the various theories.
- Explain the impact of El Niño and La Niña.
- Describe carbon sequestration policies related to climate change.

Course Content:

Section A

Concept of Climate change, Indicators and theories. Global Carbon Cycle: Stocks and Fluxes of Carbon in terrestrial and marine ecosystems and anthropogenic impact, Carbon Sequestration Impact of El Niño and La Niña on environment, Insolation and Heat Budget.

Section B

Ozone depletion: Mechanism and consequences Impact of acid rain on environment Photochemical smog: Mechanism and formation, Impact of Deforestation, Mining on environment.

Section C

Policy Perspective: UNFCCC, Role and Function of IPCC, Kyoto Protocol and its implication on Developed and developing countries. Clean Development Mechanism (CDM) and its operation Environmental protection efforts in India and abroad.

Recommended Books:

1. Bal, A. S. (2009). *An Introduction to Environmental Management*(1sted.). Mumbai, India: Himalaya.
2. Bayon, R., Hawn, A., & Hamilton, K. (2009). *Voluntary Carbon Markets*(2nded.). Abingdon, United Kingdom: Routledge.
3. Hester, R. E., & Harrison, R. M. (Eds.). (2010). *Carbon capture: sequestration and storage* .Cambridge, United Kingdom: Royal Society of Chemistry.
4. Kumar, S. (2011). *Protecting Environmental Issues- A Quest for NGO's*. New Delhi, India: AVON.
5. Rajagopalan, R. (2014). *Environmental Studies*(2nded.). New Delhi, India: Oxford University Press.
6. Singh, S. (2015). *Environmental Geography*.Allahabad, India: Pravalika.
7. Strahler, A.N. (1988). *Earth Science*. New Delhi, India:Harper and Row.
8. Wilson, E., & Gerard, D. (2007). *Carbon Capture and Sequestration Integrating Technology, Monitoring, Regulation*. Ames, IA: Blackwell.

Suggested e-learning materials:

1. Climate Change

<https://swayam.gov.in/courses/5257-climate-change>

<https://nptel.ac.in/courses/119106008/40>

Climate Change and Future Crisis

Max. Marks : 100

L	T	P	C
0	0	0	2

Learning Outcomes:

After the completion of this course, students will be able to:

- Explain and analyze climate change.
- Predict consequences of climate change over several sectors of economy.
- Analyze effects of climate variability on domestic livestock.
- Describe current and past climate change policies in India.

Course Content:

Climate Change; Global warming and regional effect; Projected impact of climatic change in Asia over fisheries, human settlement, food supply, farming systems, health; Climate change and diseases; Climate Change and El-Nino; Impact of climate change on agriculture, soil, desertification (special reference to Rajasthan); Effects of climate variability on domestic livestock; Economics of climate change; Climate change policies of India.

Recommended Books:

1. Singh.A.(2015). *Climate Change and Agriculture*. Jaipur, India: Oxford Book Company.
2. Sharma, H.S.(2018). *Climate Change and Natural resource: A study of Indian Deserts*. New Delhi, India: Global.
3. Baros, V., & Field, C.B.(2014). *Climate Change, Impacts Adaptation and Vulnerability Part B Regional Aspect.*, New York, NY : Cambridge University Press.
4. Cowie, J.(2007). *Climate change and Biological Impacts*. Cambridge, UK : Cambridge University Press.
5. Agarwal, S.K. (2013). *Global Warming and Climate change*. New Delhi, India: A.P.H.
6. Romm, J. (2018). *Climate change what everyone needs to know*. New Delhi, India: Oxford University Press.

Suggested e-learning materials:

1. El-Nino and climate Change
<https://blogs.ei.columbia.edu/2016/02/02/el-nino-and-global-warming-whats-the-connection/>
2. Economics of climate change
<https://bfi.uchicago.edu/events/CC-climate>
3. Climate change policies in India
<http://envfor.nic.in/division/india-taking-climate-change-24-recent-initiatives>

Energy Resources and Conservation

Max. Marks : 100

(ESA: 100)

L	T	P	C
0	0	0	2

Learning Outcomes:

After the completion of this course, students should be able to:

- Describe the non-conventional sources of energy.
- Explain concepts on energy utilization and conservation.
- Emphasize energy conservation strategies in residential, industrial and transportation sector.
- Describe National Energy Policy.

Course Content:

Introduction: Energy, work and power. Classification of energy resources, An overview of the current global and National Energy Scenario. Fossil Fuels: Sources, exploration of oil, coal, natural gas, shale; Exploitation of Fossil fuels and their Environmental consequences. Nuclear Energy: Nuclear fission and Fusion; Nuclear fuel cycle, Nuclear reactor and nuclear power, Renewable and Alternative Energy Sources, Solar energy, solar power, Photovoltaic cells; Wind power; Geothermal energy; Ocean energy. Environmental consequences of biomass resource harnessing, Energy Conservation: National Energy Policy, Energy efficient appliances, BEE Label, Modes of Energy Conservation in residential, industrial and transportation sector.

Recommended Books :

1. Agarwal, S. K. (2003). *Nuclear Energy: Principles Practice and Prospects*. New Delhi, India: APH.
2. Chaturvedi, P. (1995). *Bio-Energy Resources*. New Delhi, India: Concept.
3. Dayal, M. (1997). *Renewable Energy: Environment and Development*. New Delhi, India: Konark.
4. Mahajan, V. S. (1991). *National Energy: policy, crisis and growth*. New Delhi, India: Ashish.
5. Markuszewski, R., & Blaustein, B. D. (1986). *Fossil fuels utilization. Environmental concerns*. Washington, DC: American Chemical Society.
6. Vandana, S. (2002). *Alternative Energy*. New Delhi, India: APH.

Suggested e-learning materials:

1. Biodiesel production
<https://nptel.ac.in/courses/102105058/52>
2. Sustainability through Green Manufacturing Systems: An Applied Approach
<https://nptel.ac.in/courses/112104225/22>

Man and Environment

Max. Marks : 100

(ESA: 100)

L	T	P	C
0	0	0	2

Learning Outcomes:

After the completion of this course, students should be able to:

- Describe the complex interactions of humans and ecological systems in the natural world.
- Synthesize, and apply a wide range of scientific literature in the ecological and environmental science.
- Interpret a wide range of scientific literature in ecology and environmental science.
- Apply the information in the realms of environmental sciences and sustainability.

Course Content:

Human Population, its Growth and Distribution, Environmental Deterioration associated with population growth, Man Induced Environmental Changes, Types of Human Activities, Impact of Human Activities such as Deforestation, Mining and Industrialization. Environmental Awareness- Need and Role in Betterment of Environment Concept and Significance of Environmental Movements, Environmental Movements in India with special reference to The Bishnoi Movement, Chipko Movement, Appiko Movement, Narmada Bachao Andolan, Silent Valley Movement. Components of natural and built environment: Resources and human settlements, modifications in natural environment, causes and consequences.

Recommended Books :

1. Bal Anand, S. (2005). *An Introduction to Environmental Management*. Mumbai, India : Himalaya.
2. Chandana, R. (2008). *A Geography of population*. New Delhi, India: Kalyani.
3. Chopra, G. (2006). *Population Geography*. New Delhi, India: Commonwealth.
4. Chorley, R. J., Schumm, S. A., & Sugden, D. E. (1984). *Geomorphology*. London, U.K. : Methuen and Company.
5. Dayal, P. (1994). *A Text Book of Geomorphology*. New Delhi, India :Kalyani.
6. Rapoport, A. (2016). *Human aspects of urban form: towards a man—environment approach to urban form and design*. Oxford, U.K. : Elsevier Pergamon Press.

Suggested e-learning materials:

1. Environment and Ecology
<https://nptel.ac.in/courses/122102006/>
2. Ecological Degradation and Environmental Protection
<https://nptel.ac.in/courses/109104045/35#>

Agroforestry

Max. Marks : 100

(ESA: 100)

L	T	P	C
0	0	0	2

Learning Outcomes:

After the completion of this course, students should be able to:

- Describe agroforestry and agroforestry interventions.
- Assess the role of Agroforestry as a sustainable land-use activity.
- Describe Nutrient cycling and role of agroforestry in soil and water conservation
- Describe various energy plantation methods.

Course Content:

Agroforestry - definition and scope. Tropical deforestation, rising demands of fuel wood, fodder and timber, social, ecological and economic reasons for agroforestry. Traditional agroforestry systems: shifting cultivation, taungya, homegardens. Recent trends in Silviculture and Energy plantations. Trees in agricultural fields and farm boundaries. Commercial crops under shade of planted trees as well as natural forests. Agroforestry for wasteland development and temperate agroforestry practices. Nutrient cycling and role of agroforestry in soil and water conservation, Nitrogen fixation, improvement in soil physico-chemical properties. Soil organic matter status and soil organic matter, Soil fertility considerations in agroforestry nutrient needs of trees and crops.

Recommended Books :

1. Chundawat, B. S., & Gautam, S. K. (2016). *Textbook of Agroforestry*. New Delhi, India: Oxford & Ibh.
2. Jose, S. (2009). *Agroforestry for Ecosystem Services and Environmental Benefits (Advances in Agroforestry)*. Dordrecht Netherlands: Springer
3. Mukherjee, A. (2016). *Agroforestry and Watershed Management: An Interlocked System*. New Delhi, India: Random.
4. Raj, A. J. (2017). *Agroforestry Theory and Practices*. Jodhpur, India: Scientific.

Suggested e-learning materials:

1. Introductory Agroforestry
<http://ecoursesonline.iasri.res.in/course/view.php?id=157>
2. Forestry Technologies
http://agritech.tnau.ac.in/forestry/agroforestry_index.html

Third Semester

Air Pollution Monitoring, Control Technology and Management

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

After the completion of this course, students will be able to:

- Describe various air pollutants and their sources.
- Describe the consequences on human health.
- Predict the control measures of air pollutant depending upon source and type.
- Illustrate stack sampling and mitigation strategies of SO_x and NO_x

Course Content:

Section A

Air pollution: Definition, sources and effects. Air pollutants; Classification and properties, emission sources, major emissions from global sources and importance of Anthropogenic sources.

Effects of air pollution on health, vegetation and materials damages. Photochemical smog.

Section B

Control techniques and equipments for air pollution, particulate emission control: Gravitational settling chambers, cyclone separators, fabric filters, electrostatic precipitator, wet scrubbers.

Control of specific gaseous pollutants; control of SO_x, control of NO_x, control of hydrocarbons, and control of carbon mono-oxide

Section C

Air pollution sampling and measurement: Types of pollutant sampling and measurement, ambient air sampling, collection of gaseous air pollutants, collection of particulate pollutants, stack sampling, analysis of air pollutants

Recommended Books:

1. Buonicore, A., & Theodore L. (1994). *Air Pollution Control Equipment: Selection, Design, Operation and Maintenance*. New York, NY: Springer-Verlag.
2. Buonicore, A., Wayne, T., & Davis (1992). *Air Pollution Engineering Manual*. New York, NY: Van Nostrand Reinhold.
3. Burke, G., Singh, B. R. & Theodore, L. (2000). *Handbook of Environmental Management and Technology* (2nd ed.). New York, NY: John Wiley & Sons.
4. Cavaseno, V. (1980). *Industrial Air Pollution Engineering*. New York, NY: Mcgraw-Hill.

5. Cheremisinoff, N. P. (2002). *Handbook of Air pollution prevention and control*. Oxford, UK: Butterworth-Heinemann Elsevier science.
6. Cheremisinoff, P. N. (1993). *Air Pollution Control and Design for Industry*. New York, NY: Marcel Dekker.
7. De, N. N. (2000). *Air Pollution Control Engineering*(2nd ed.). New York, NY: McGraw-Hill Companies.
8. Heinsohn, R.J. &Kabel, R.L. (1999). *Sources and Control of Air Pollution*.New Jersey,NJ:Prentice.
9. Kovacs, M. 1995. *Pollution Control and Conservation*. Chichester: Ellis Horwood.
10. Kumar, S. & Kumar, R. (2012) *Air Quality – Monitoring and Modeling*. Croatia, Rijeka:In TechJanezaTrdine.
11. Lodge, J. P. (1988). *Methods of Air Sampling and Analysis* (3rded.). Boca Raton, FL: Lewis.
12. Metcalf & Eddy, Inc. (1991). *Wastewater Engineering-Treatment, Disposal and Reuse* (3rd ed.). New York, NY: McGraw-Hill.
13. Stern, A. C. (1976). *Air Pollution Measuring, monitoring and surveillance of air pollution* (3rd ed.). Massachusetts, MA: Academic Press.
14. Stern, A. C. (1986). *Air Pollution. Supplement to measuring, monitoring and surveillance and engineering control of air pollution*(3rd ed.).Massachusetts, MA: Academic Press.
15. William, F., & DeRose, (2004) *Principles and Practices of Air Pollution Control*, United States Air Pollution Training Institute (APTI)

Suggested e-learning materials:

1. Environmental air pollution
[https://nptel.ac.in/courses/105102089/air%20pollution%20\(Civil\)/Module-2/1.htm](https://nptel.ac.in/courses/105102089/air%20pollution%20(Civil)/Module-2/1.htm)
2. Stack Monitoring
<https://nptel.ac.in/courses/105102089/8>
3. Guidelines for the Measurement of Ambient Air Pollutants
<http://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMjdfMTQ1ODExMDQyNi90ZXJdJdGVtXzE5Ni90QUFRTVNfVm9sdW1lLUkucGRm>
4. Air pollution control technologies <http://capacitydevelopment.unido.org/wp-content/uploads/2014/11/25.-Air-Pollution-Control-Technologies-Compendium.pdf>
Kinetics of Air Pollution and Combustion Process <https://nptel.ac.in/courses/105104099/>

Renewable Energy Resources

Max. Marks : 100

L T P C

(ESA: 100)

0 0 0 2

Learning Outcomes:

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

- Understand the various forms of conventional and non conventional energy resources.
- Design working models of renewable energy.
- Understand the applications and limitations of renewable energy sources.

Section A

Availability, importance, utilization, economics and growth rates of renewable energy sources. Combustion calculations, Conventional thermal power plant design and its operation, Superheat, reheat and regeneration, Other auxiliaries of thermal plant. High– pressure boilers, Steam generator control. Biomass and its types, Biomass fuel characterization; thermo chemical and biochemical processes; reaction kinetics; energy and mass balance equations; studies of processes and system design for gasification, pyrolysis and liquefaction of biomass. Biochemical and thermochemical conversion of biomass. Design of biogas plants and gasifiers; Fuel related properties of biomass; planning and management of biomass collection, utilization, handling and pre-conditioning processes such as size reduction and densification; combustion, pyrolysis and gasification of biomass, photosynthetic efficiency, plant productivity and bio-energy yield, biomass waste.

Section B

Chemistry, process and performance analysis of biofuels; alcohol production: pre-treatment of biomass, fermentation with process details and dehydration; operational performance of I.C. engines on producer gas, biogas, alcohol, and plant oils and their esters. Solar radiation intensity and solar geometry. Analysis and design of non-concentrating and concentrating solar collectors. Solar energy storage techniques, Steady and transient heat transfer analysis of solar cookers, solar ponds, solar stills and solar dryers. Design of solar thermal systems; hot water systems, space heating and cooling systems, solar drying system for agricultural produce etc. Economic analysis of solar energy systems. Design of solar energy operated systems for heating, cooling, distillation, drying, dehydration, water pump and power generation for applications in agriculture.

Section C

Basic principles of wind energy conversion, site selection considerations, classification advantages and disadvantages of Wind Energy Conversion System (WECS), types of wind machines, performance of wind machines, Utilization of wind energy for generating electricity and mechanical power. Types of wind mill and their characteristics. Mechanics of wind mills. Introduction to geothermal energy and storage, hydrothermal resources, geo-pressured resources, petro-thermal resources, prime movers for geothermal energy conversion, applications of geothermal energy. Basic principle of tidal power, components of tidal power plant, site requirements, storage of tidal energy, advantages and limitations of tidal power generation. Photo-Voltaic devices. Applications of renewable energy sources.

Recommended Books:

- Ching T. Hou and Jei Fu Shaw, Biocatalysis and Bioenergy, John Wiley & Sons, 2008.
- G.D. Rai, Non-Conventional Energy Sources, Khanna Publishers.
- Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, Oxford University Press, U.K, 1996.

- H. P. Garg, J. Prakash, Solar Energy: Fundamentals and Applications: Fundamentals and Applications 1 Edition, Tata Mcgraw Hill Education Private Limited (2000).
- Johnson Gary, L., Wind Energy Systems, Prentice Hall, New York, 1985.
- L.L. Freris, Wind Energy Conversion systems, Prentice Hall, UK, 1990.

Resource: Challenges and Management

Max. Marks : 100

L	T	P	C
0	0	0	2

Learning Outcomes:

After the completion of this course, students will be able to:

- Analyze the resources and their scarcity.
- Depict the problems arising from resource scarcity.
- Describe resource related problems.
- Suggest measures to conserve resources like water, forest, energy, biodiversity etc.

Course Content:

Resource and Technological Development Stages; Use and misuse of resources; Resource depletion and emerging issues: desertification, deforestation, Loss of Biodiversity, Energy crises, water scarcity and conflicts; Future prospects of energy resources with special reference to India; Resource disputes: river water sharing in India (Narmada, Krishna, Cauvery and Sutlej Yamuna Link-SYL); Conservation of resources (Water, Forest and Energy); Community participation and resource management; Watershed as a unit of resource management; Resource management in India with special reference to arid regions.

Recommended Books:

1. Gautam, A. (2010). *Advanced Economic Geography*. Allahabad, India: Sharda Pustak Bhawan.
2. Guha, J.L., & Chattoraj, P.R. (2009). *Economic geography – A Study of Resources*. (9thed.). Kolkata, India: The World Press.
3. Hartshorn, T. A., & Alexander, J. W. (2009). *Economic Geography*. (8thed.). New Delhi, India: Prentice Hall.
4. Jetli K Narindra (2010). *Human and Natural Resource of India*. New Delhi, India: New Century.
5. Khullar, D. R. (2014). *India, A Comprehensive Geography*. (3rd ed.). Ludhiyana, India: Kalyani.
6. Leong, G. C., & Morgan, G. C. (2010). *Human and Economic Geography*. (2nded.). New Delhi, India: Saurabh
7. Pandey B.M (2005) (Ed.) (2005). *Natural Resource Management*. New Delhi, India: Mittal.
8. Qazi S.A. and Qazi N.S (2007). *Natural Resource Conservation*. New Delhi, India: APH.
9. Siddharth, K. (2018). *Economic Geography*. (3rded.). Allahabad, India: KitabMahal.
10. Singh, Gopal. (2010). *Geography of India*. (9th ed.). Delhi, India: Atma Ram.
11. Trivedi P.R. (2010). *Natural Resource Conservation*. New Delhi, India: APH.
12. बंसल, एस. सी. (2015). *भारत का भूगोल* (तृतीय संस्करण). मेरठ, भारत: मीनाक्षी.
13. मामोरिया, सी. (2018). *भारत का वृहत भूगोल*. आगरा, भारत: साहित्य भवन.
14. सिंह, के. (2009). *आर्थिक भूगोल के मूलतत्व : संसाधन उपयोग, संरक्षण एवं आर्थिक विकास का अध्ययन* (11 वॉ सं). वाराणसी, भारत: ज्ञानोदय.
15. सिंह, जे. (2009). *संसाधन भूगोल*. नई दिल्ली, भारत: राधा.

Suggested e-learning materials:

1. Resource Scarcity
<https://www.ipinst.org/wp-content/uploads/2015/06/rscar0408.pdf>
2. Resource Scarcity and adequacy
<http://www.yourarticlelibrary.com/economy/important-ideas-concepts-developed-in-economy/25276>
3. Use and misuse of natural resource
<https://www.ugc.ac.in/oldpdf/modelcurriculum/Chapter2.pdf>
4. Economic development and Resource
<https://helpsavenature.com/how-do-natural-resources-affect-economic-development>.
5. Watershed and resource management
http://kiran.nic.in/pdf/publications/Watershed_Development.pdf

Environmental Psychology

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
5	0	0	5

Learning Outcomes:

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

- Evaluate the ethical, cross-cultural, and historical context of environmental issues and the links between human and natural systems.
- Explain the transnational character of environmental problems and ways of addressing them, including interactions across local to global scales.
- Apply systems, concepts and methodologies to analyze and understand interactions between social and environmental processes.

Section A

1. Nature and Scope of Environmental Psychology.
2. Theories and Approaches and Research methods of Environmental Psychology.
3. Environmental Perception and Cognition.
4. Environmental Attitudes, Appraisals and Assessments.
5. Personality and Environment: Dimensions, some uses of personality in environmental Design.

Section B

6. Personal Space: Measurement, Factors, Theories and Designs
7. Territoriality: Measurement, Factors, Theories and Designs
8. Crowding: Measurement, Factors, Theories and Designs
9. Privacy: Measurement, Factors, Theories and Designs
10. Residential Environment: Preferences, Choices and Satisfaction, Residential Mobility and Designs, Stress and Well-Being

Section C

11. Community Environment: Neighborhood Satisfaction and Attachment, Antisocial and Helpful Behavior in the Community Environment, Community Environmental Designs and Environmental Psychology of Shopping.
12. Educational Environment : Setting as a whole, Interior Architecture and Design, Noise, Light and Color, Climate, Space and Environmental Competence, Learning and Environmental Designs
13. Workplace Environment: Environmental Psychology on the Job, Work, Travel and Environmental Design
14. Managing Limited Environmental Resources: Pubic Interest Resource Management, Dilemma of Resource Management, Social Dilemma and its Theories.

Recommended Books:

1. Altman, I. (1976): *Human Behavior & Environment: Advances in Theory and Research*. Plenum Press.
2. Altman, I. (1986): *Advances in Environment, Behavior & Design*. Vol. I-IV. Plenum Press.
3. Bell, A.P., Fisher J.D., & Looms, R.S. (1978). *Environmental Psychology*. W.B. Sanders and Company.
4. Gifford. R. (1997). *Environmental Psychology* (2nd edition). Allyn and Bacon.

5. McGurk, H. (1978). *Ecological factors in Human Development* (Eds.). North-Hollow Publishing Company: Amsterdam Oxford.
6. Nickerson, R.S. (2003). *Psychology and Environmental Change*. Lawrence Erlbaum Associates.
7. Stokols, D. & Allman, I. (1987). *Handbook of Environmental Psychology* (Edited). Wiley Publication.

Suggested E-learning Material:

- Psychology of environmental psychology
<https://www.pdfdrive.com/psychology-of-environmental-psychology-e52254718.html>
- Environmental psychology: Developmental approaches
<https://www.pdfdrive.com/environmental-psychology-new-developments-e33425685.html>
- Handbook of environmental psychology
<https://www.pdfdrive.com/handbook-of-environmental-psychology-e33549991.html>

Safe and Healthy Environments for Young Children

Total Marks : 100
(ESA : 100)

L	T	P	C
0	0	0	2

Learning Outcomes:

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

- Evaluate strategies for the promotion of good health for families, teachers and children in culturally, linguistically, and developmentally appropriate ways
- Identify health, safety, and environmental risks in children's programs
- Analyze the nutritional needs of children at various ages and evaluate the relationship between healthy development and nutrition

Content

- Introduction to the laws, regulations, standards, policies and procedures related to child health, safety, and nutrition
- Serving Healthy Food and Drinks to Children in Child Care Programs
- Personal health of the individual, including nutrition, health and safety issues
- Understand how child development influences the risk of injury, conditions in which common childhood injuries occur, safety practices and routines to reduce the risk of children's injuries
- Understand how to establish, communicate, and promote written policies for and safety in child care programs, tools and resources to keep child care programs safe for children
- Roles and responsibilities of the individual, team and community, current health and safety information
- Types and levels of child abuse and knowing how to respond to various situations in a professional manner
- National legislation and regulations regarding human rights, child protection, health and safety as they relate to diverse early learning and care environments

Suggested Readings:

1. Marotz, L.R. (2015). *Health, Safety and Nutrition for the Young Child*. 9th Edition, Cengage Learning, Inc
2. Sayre, N.E. Gallagher, J. (2000). *The Young Child and the Environment: Issues Related to Health, Nutrition, Safety, and Physical Activity* 1st Edition. Pearson

Solid Waste Management for a Smart City in India

Max. Marks : 100

L	T	P	C
0	0	0	2

Learning Outcomes:

After the completion of this course, students will be able to:

- Understand about the concept, characteristics, rules of solid waste management.
- Learn about biochemical processes and energy recovery from municipal solid waste.
- Learn about the collection, transportation, segregation, composting and disposal of Municipal solid Waste.
- Assess the issues and challenges of Solid Waste Management faced in India.

Course content:

Municipal Solid Waste Management: Characteristics and Quantities, Collection, Transportation, Segregation, Processing and Disposal of Municipal Solid Waste, Landfill; Biochemical Processes and Composting; Energy Recovery from Municipal Solid Waste; Current Issues in Solid Waste Management; Construction and Demolition (C&D) Waste Management – Overview; C&D Waste – Regulation, Beneficial Reuse of C&D Waste Materials; MSW Rules 2016, Electronic Waste (E-Waste) Management – Issues and Status in India; E-Waste Management Rules 2016 and Management Challenges, Swachh Bharat Mission so far.

Recommended Books:

1. Bhatia, S. C. (2007). *Solid & Hazardous Waste Management*. New Delhi, India: Atlantic.
2. Hosetti, B. B. (2016). *Prospects & Perspectives of Solid waste Management*. New Delhi, India: New Age International.
3. Mohd, S. (2011). *Waste Management in an Urban Area*. New Delhi, India: B. R.
4. Singh, J. & Ramanathan, A. L. (Ed.), (2015). *Solid waste Management Present & Future Challenges*. New Delhi, India: I.K. International.
5. Yasmin, S. (2013). *Solid waste Management*. New Delhi, India: Global Research.

Suggested e-learning materials:

1. MSW Management Rules 2016, Govt. of India
<http://cpcb.nic.in/>
2. Electronic Waste Management Rules 2016, Govt. of India
<http://cpcb.nic.in/>
3. Biochemical Processes and Composting
http://ecochem.com/t_compost_faq2.html
4. Energy Recovery from Municipal Solid Waste
<https://www.epa.gov/smm/energy-recovery-combustion-municipal-solid-waste-msw>

Systematic Agricultural Geography

Max. Marks : 100

L T P C

(CA: 40 + ESA: 60)

5 0 0 5

Learning Outcomes:

After the completion of this course, students should be able to:

- Describe approaches to study agricultural geography.
- Apprise farmers about new farming techniques, influencing patterns and environmental degradation caused by agriculture.
- Demarcate any region according to world classification systems through statistical techniques.
- Classify land on several parameters and discuss the nature of agricultural problems of the nation.

Course Content:

Section A

Nature & Scope of Agricultural Geography

Nature, scope and significance of Agricultural Geography; Approaches to the study of Agricultural Geography – Commodity Approach, Regional Approach and systematic approach; Factors influencing patterns and farm techniques; Soils – Major soil types, distribution & their characteristics; Environmental degradation – Causes and consequences.

Section B

Agricultural Regions & Typology

Whittleseys's classification of Agricultural systems of the world; Agricultural location theory of Von-Thunen and their limitations; Concept of Agricultural regions and delimitation; Agricultural Typology-Kostrowicki; Methods of Delimitations of crop combination Region – J.C. Weaver's minimum deviation and K. Doi's least square method.

Section C

Modern Concepts of Agricultural Geography

Concepts in Agricultural Geography– Sustainable development, Social forestry, Agribusiness, and dryland farming; Land classification and land capability; Agricultural transformation in India posts Independence – Land reforms and land use policy; Green revolution its implications in India and impact of white revolution in India; Food deficit and surplus regions of India, Problems of Indian Agriculture, management and planning, National Agriculture Policy.

Stencils and non-scientific calculators are to be permitted during the examination.

Recommended Books:

1. Chauhan, D. S. (2010). *Agricultural Geography*, Jaipur, India: Ritu.
2. Gautam, A. (2012). *Agricultural Geography*, Allahabad, India: Sharda Pustak Bhawan.
3. Hussain, M. (2010). *Agricultural Geography*, New Delhi, India: Rawat.
4. Kostowickie (1983). *Agricultural Typology*, Warsaw, Poland: Polish Academy.

5. Leong, G. C., & Morgan, G. C. (2010). *Human and Economic Geography* (2nd ed.). New Delhi, India: Saurabh.
6. Ali, M., & Hanafi, Y. S. (2013). *Agricultural Geography*. Gorakhpur, India: Vasundhra.
7. Ali, M. (1979). *Dynamics of Agriculture Development in India*, Delhi, India: Concept.
8. Ali, M. (1981). *Situation of Agricultural Geography*. New Delhi, India: Rajesh.
9. Shafi, M. (2006). *Agricultural Geography*. Delhi, India: Baba BarkhaNath.
10. Singh, J., & Dhillon, S. S. (2004). *Agriculture Geography* (3rd ed.). New Delhi, India: Tata McGraw – Hill.
11. कुमार, पी., एवं शर्मा, के. (2008). *कृषि भूगोल* (अष्ट सं.) भोपाल, भारत: मध्य प्रदेश हिन्दी ग्रन्थ अकादमी.
12. गौतम, ए. (2009). *कृषि भूगोल*. इलाहबाद, भारत: शारदा पुस्तक भवन.
13. हुसैन, एम. (2010). *कृषि भूगोल* (द्वितीय सं.) जयपुर, भारत: रावत.

Suggested e-learning materials:

1. White Revolution in India
[http://lnweb90.worldbank.org/oed/oed/doclib.nsf/fb71ec897615187985256885007b6ad0/1bdd436f3bb1c0d68525684800767e4e/\\$FILE/India_Dairy.pdf](http://lnweb90.worldbank.org/oed/oed/doclib.nsf/fb71ec897615187985256885007b6ad0/1bdd436f3bb1c0d68525684800767e4e/$FILE/India_Dairy.pdf)
2. Agribusiness
http://www.isapindia.org/uploads_isap/annual_report/1010_Report-2016-17.pdf

Geo Tourism

Max. Marks : 100
(ESA: 100)

L	T	P	C
0	0	0	2

Learning Outcomes:

After the completion of this course, students should be able to:

- Elucidate the criterion require for designating geotour sites.
- Explore the geological and geographical attributes of the geosites.
- Develop a geo-conservation plan for geotour sites.
- Evaluate the potential of geosites for revenue generation.

Course Content:

Definition and scope of Geotourism. Principles of Geotourism. Geoconservation Plans. Introduction to geodiversity and Geopark. UNESCO's Global Geopark development program. Overview of GSI monuments and geotour sites- Sendra Granite of Pali District Rajasthan. Lonar Lake of Buldana District Maharashtra, Peninsular Gneiss at Lalbagh Bangalore Karnatakam, Natural Arch in Tirumala hills Chittoor District, Barr Conglomerate Pali District Rajasthan, Marine Gondwana Fossil Park, Fossil Wood Parks, Siwalik Fossil Park, Stromatolite Parks, Columnar Basalt, Pillow Lava, Pyroclastic Rocks, Nepheline Syenite, Welded Tuff, Charnockite, Great Boundary Fault, Eparchaeon Unconformity, Tirumala hills. World's major geotour sites.

Recommended Books :

1. Chen, A. (2015). *The Principles of Geotourism*. Beijing, China: Springer-Verlag.
2. Dowling, R., & Newsome, D. (Eds.). (2018). *Handbook of Geotourism*. Gloucestershire, UK: Edward Elgar.
3. Dowling, R., & Newsome, D. (Eds.). (2005). *Geotourism*. Oxford, UK: Elsevier.
4. Newsome, D., & Dowling, R. (Eds.). (2010). *GEOTOURISM: The Tourism of Geology and Landscape*. Oxford, UK: Goodfellow.

Suggested e-learning materials

1. UNESCO geological heritage and geo-tourism in Peru
http://www.unesco.org/new/en/media-services/single-view/news/unesco_geoparks_geological_heritage_and_geo_tourism_in_peru/
2. Geotourism
https://link.springer.com/referenceworkentry/10.1007%2F978-3-319-01669-6_93-1
3. Geotourism in India
<https://www.gsi.gov.in>

Geography of Environmental Management

LT PC

4 0 0 4

Max. Marks : 100

(CA: 40 + ESA: 60)

1. Environment: Fundamentals of Environment
2. Biodiversity: meaning, importance and types; Biodiversity hot spots; Loss of Biodiversity and its conservation
3. Environmental Degradation: Meaning and types of degradation; Quality Assessment of Soil and Water.
4. Environmental Impact Assessment and Strategies; Case Studies: Tehri Dam, Sardar Sarovar Project
5. Concept of Sustainable Development
6. Concept of Eco-feminism and Eco-socialism
7. Environmental Challenges and Management in India: Desertification, Mining, Deforestation, Waste Disposal and Big Dam Controversy – Issues related with high dams (Narmada Sagar Project, Silent Valley); Eutrophication of Wetlands
8. Environmental Movements in India: Chipko Movement and Narmada Bachao Andolan
9. Case studies Associated with Environmental Degradation: Famines in Tribal belt of Rajasthan; Jhum Cultivation in Meghalaya
10. Disaster: A case study of Uttarakhand disaster (Kedarnath disaster, 2013).

Books Recommended:

1. Bhattacharya, N.N. (2011), Biogeography, Rajesh Publications, New Delhi.
2. Chandna R.C., (2010), Environmental Geography, Kalyani publishers, New Delhi.
3. Gautam A., (2010), Environmental Geography, Sharda Pustak Bhavan, Allahabad.
4. Jadhav, S.B., (2012), Environmental Geography, Chandralok Prakashan, Kanpur.
5. Moirangleima, Kh. (2010), Sustainable Management of Wetlands Central Valley of Manipur, B.R. Publishers, New Delhi.
6. Nag, P., et.al, (1997), Geography and Environment, (ed.) Concept Publishing Company, New Delhi.
7. Raghavan, .K. M., (2014), Environmental Geography and Disaster Management, Navyug Books International, Delhi.
8. Salahuddin, M., (2011), Waste Management in an Urban Area, B.R. Publishers, New Delhi.
9. Saxena H.M., (2011), Environmental Geography, Rawat Publications, Jaipur.
10. Singh Onkar, et.al. 1993, Frontiers in Environmental Geography, (ed.) Concept Publishing Company, New Delhi.
11. Singh Savindra, (2010), Environmental Geography, Prayag Pustak Bhavan, Allahabad.

Hydrogeology

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

After the completion of this course, students should be able to:

- Explain the distribution and movement of groundwater in the soil and rocks of the Earth's crust.
- Describe hydrological cycle and related parameters.
- Determine the physical and chemical parameters to assess groundwater quality.
- Evaluate the major geological factors controlling groundwater exploration.

Course Content:

Section A

Introduction and scope of hydrogeology. Groundwater: origin and age of groundwater. Hydrological cycle, Vertical distribution of groundwater. Water table, Porosity, Permeability, Zone of saturation: specific yield and retention.

Section B

Aquifers: Characteristics and types. Darcy's law, hydraulic conductivity. Well hydraulics: Confined and Unconfined. Groundwater modeling: Types and steps in development of groundwater model.

Section C

Water Sampling. Groundwater quality. Saline water intrusion: Groundwater regimes in India. Groundwater exploration (Geological and Geophysical methods). Artificial recharge of groundwater. Rain water harvesting.

Recommended Books:

1. Arul, P. (2000). *A textbook of groundwater*. Virudachalam, India: Dhanam.
2. Karanth, K.R. (1989). *Hydrogeology*. New Delhi, India: Tata McGraw Hill.
3. Nagabhushaniah, H. S. (2001). *Groundwater in Hydrosphere*. New Delhi, India: CBS.
4. Raghunath, H. M. (2014). *Groundwater* (3rded.). New Delhi, India: New Age International.
5. Todd, D. K., & Mays, L. W. (2004) *Groundwater Hydrology* (3rded.). New Delhi, India: Wiley India.

Suggested e-learning materials:

1. Introduction to hydrogeology

<https://epgp.inflibnet.ac.in/ahl.php?csrno=448>

2. Ground water hydrology

<https://nptel.ac.in/courses/105105106/>

India: Socio-Political and Environmental Scenario

Max. Marks : 100

(ESA: 100)

L	T	P	C
0	0	0	2

Learning Outcomes:

After the completion of this course, students should be able to:

- Understand the current issues related with boundaries, water sharing, agricultural disparities, food security in India.
- Describe problems in Agricultural Development.
- Discuss Gender Issues and Women Safety.
- Find the role of non – conventional energy resources for solving energy crisis.

Course Content:

Relation of India with neighbouring countries and border disputes with China and Pakistan. Drought problems, Interlinking of rivers as a solution of water crises and disputes of river water sharing with reference to Narmada, Krishna, Cauvery and Sutlej Yamuna Link (SYL). Problems and disparities in agricultural development, food security and farmer suicides in India. Energy crisis in India and its solution with the help of nuclear, solar, hydro and wind power. Gender issues and women safety, poverty and unemployment.

Recommended Books :

1. Deshpande, C. D. (1992). *India, A Regional Interpretation*. New Delhi, India: ICSSR & Northern Book Centre.
2. Gallaher, C. et al. (2012). *Key Concepts in Political Geography* (Reprint). New Delhi, India: Sage.
3. Hussain, A. (2007). *Political Geography*. New Delhi, India: Vishvabharti.
4. Singh, R. L. (Ed.).(1971). *India - A Regional Geography*. Varanasi, India: National Geographical Society.
5. Tirtha, R., & Gopal, K. (1996). *Emerging India*. Jaipur, India: Rawat.
6. बंसल, एस. सी. (2011). *भारत का भूगोल*. मेरठ, भारत: मीनाक्षी.

Suggested e-learning materials:

1. Interlinking of rivers
https://www.geoecomar.ro/website/publicatii/Nr.19_2013/12_mehta_web_2013.pdf
2. Farmer suicides
http://www.ipcinfo.org/fileadmin/user_upload/fsn/docs/Agriculture%20and%20rural%20development%20in%20India.pdf
3. Food Security
https://dfpd.nic.in/LwB3AHIAaQB0AGUAcgBIAGEAZABkAGEAdABhAC8AUABvAHIAAdABhAGwALwBNAGEAZwBhAHoAaQBUAGUALwBEAG8AYwB1AG0AZQBwAHQALwA=1_93_1_Original.pdf
4. Gender Issues in India
<https://www.indiacelebrating.com/social-issues/gender-inequality-in-india/>

Industrial Economics

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
5	0	0	5

Learning Outcome:

After completion of the course, the student will be able to:

- Understand basic issues such as pricing policy, efficiency, demand analysis, forecasting, productivity and capacity utilization.
- Examine the internal structure of firms.
- Analyse various aspects of strategic interaction between firms and the determinants of industrial structure.
- Discusses the role of policy in the context of competition and industrial policies and regulation.
- Apply theoretical tools to analyse real issues.
- Learn industrial economics in cogent and analytical manner particularly in the Indian context.

Section A

Scope and Methodology of industrial economics; Market structure and behaviour of a firm; Productivity; efficiency and capacity utilization; Methods of measuring efficiency of a firm, Diversification, Integration and Merger; Industrial finance: Sources, structure, access and institutions.

Section B

Elasticity of Demand and business decision-making; Demand forecasting; Pricing procedures theoretical and pricing in practice; Investment decisions; financial statement and ratio analysis; Economics of patents; Recent provisions of patent rights in India.

Section C

Separation of ownership and control; Industrial relations: Definition and scope; Economics of union: Bargaining theories of wages; The economic theory of regulation; The current measures of regulation of industries in India; Current industrial policy in India, Industrial growth in India: Trends and prospects; takeover code of SEBI; Competition policy; price policy.

Recommended Books:

1. Bain, J.E. (1959). Industrial Organization. New York: Wiley and sons.
2. Barthwal, R.R. (1984). Industrial Economics. An Introductory Text book. New Delhi: Wiley Eastern Ltd.
3. Brahmananda P.R. (1987). Productivity in the Indian Economy. Bombay: Himalayan Publication.
4. Chandra, P. (1987). Project Preparation, Appraisal, Budgeting and Implementation. New Delhi: Tata McGraw-Hill.
5. Cherunilam, F. (1994). Industrial Economics. Mumbai: Himalaya Publishing House.
6. Church J.R. and R. Ware. (2000). Industrial Organization: A Strategic Approach. Irwin McGraw-Hill.
7. Clarkson K.W. and R. Millar. (1985). Industrial Organization: Theory, Evidence and Public Policy. Tokyo: McGraw-Hill, Kogakusha.
8. Clement Krouse. (1990). Theory of Industrial Economics. London: Constable.
9. Cyret, R.M. and J.G. March. (1963). Behavioral Theory of the Firm. New Jersey: Englewood cliffs.
10. Divine, P.J. et al. (1976). An Introduction to Industrial Economics. London: George Allen and Unwin Ltd.
11. Ferguson, P. R. and G. J. Ferguson. (1994). Industrial Economics: Issues and Perspectives. London: Macmillan.
12. Ghosh, P.K. (1977). Government and Industry. Delhi: Oxford University Press.
13. Hay, A.D. and Morris Derek J. (1991). Industrial Economics and Organization: Theory and Evidence. Oxford: Oxford University Press.
14. Hennah, L. and J. Kay. (1977). Concentration of Modern Industry. London: Macmillan.
15. Kuchhal, S.C. (1987). Industrial Economy of India. Allahabad: Chaitanya.
16. Planning Commission. (1966). Report on Industries, Planning and Licensing Policy. Government of India.
17. Shepherd, W.G. (1979). Economics of Industrial Organization. USA: Prentice Hall.

18. Smith, D.M. (1971). Industrial location: an Economic and Geographic Analysis. New York: John Wiley.
19. Tirole, J. (1988). The Theory of Industrial Organization. Cambridge: MA: MIT Press.

E- Learning Material:

1. <https://dspace.mit.edu/bitstream/handle/1721.1/48172/industrialeconom00schm.pdf>
2. <https://dspace.mit.edu/bitstream/handle/1721.1/48172/industrialeconom00schm.pdf>
3. https://www.edb.gov.hk/attachment/en/curriculum-development/kla/pshe/references-and-resources/economics/Industrial_Economics_Booklet_Eng_web.pdf
<https://london.ac.uk/courses/industrial-economics-ec3099>

Contemporary Social Challenges in India

Max. Marks : 100

L	T	P	C
0	0	0	2

Learning Outcomes:

After the completion of this course, students will be able to:

- Analyze the socio cultural environment in India with respect to parameters like sex ratio, fertility and mortality.
- Understand about the causes and consequences of Gender discrimination in Indian society.
- Status of women and domestic violence in Indian society and need of women empowerment.
- Aware about the government policies concerning them.

Course Content:

Socio-cultural transformation and its relation with environment; Social diversity, Social well-being and Quality of life in India with reference to major religion; Gender inequality in sex ratio, fertility, mortality and child marriage in India; Causes and consequences of Gender discrimination in Indian society with special reference to Literacy and occupational structure; Status of women and domestic violence in Indian society and need of women empowerment in modern India; Government Laws, Policies/schemes and International commitments to women empowerment.

Recommended Books:

1. Ahmad, A. (2006). *Social Geography* (Reprint). Jaipur, India: Rawat.
2. Chandana, R. C. (2014). *A Geography of population (11th ed.)*. New Delhi, India: Kalyani.
3. Jetli, K. N. (2010). *Human and Natural Resource of India*. New Delhi India: New Century.
4. Khullar, D. R. (2014). *India, A Comprehensive Geography.(3rd ed.)*. Ludhiyana, India: Kalyani.
5. Mehtani, S., & Sinha, A. (2010). *Social Geography*. New Delhi, India: Commonwealth.
6. Ranade, P. S. (1990). *Population Dynamics in India*. New Delhi, India: Ashish.
7. Singh, G. (2010). *Geography of India.(9th ed.)*. Delhi, India: Atma Ram.
8. Syed, M. H. (2010). *Social and Cultural Transformation in India*. New Delhi, India: Anmol.

Suggested e-learning materials:

1. Women Empowerment
<https://www.indiacelebrating.com/social-issues/women-empowerment/>
2. Socio-culture Transformation
<http://www.yourarticlelibrary.com/society/essay-on-socio-cultural-dynamics-in-indian-society/4022>
3. Social Diversity
<http://egyankosh.ac.in/bitstream/123456789/8326/1/Unit-16.pdf>
4. Gender Inequality
<https://www.indiacelebrating.com/social-issues/gender-inequality-in-india/>

5. Gender Discrimination
<http://www.dailyexcelsior.com/gender-discrimination-india/>
6. Occupational Pattern
https://www.ijmra.us/project%20doc/2018/IJRSS_JANUARY2018/IJMRA-13135.pdf
7. Domestic Violence
<https://www.youthkiawaaz.com/2010/02/domestic-violence-in-india-causes-consequences-and-remedies-2/>

Contemporary Global Issues

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Theory:

Section A

- a. Natural resources and their conservation.
 - Renewable and non-renewable.
 - Use and exploitation of natural resources.
 - Water and solid waste management.
- b. Biodiversity and its conservation.
 - Definition, types, importance and conservation.
 - Introduction to environment science and ecosystem.
 - Endangered and endemic species in India and world.
 - Threats and remedies to protect the biodiversity globally.
- c. Environmental pollution.
 - Definition, causes and types of pollution.
 - Control and preventive measures of different types of pollution.
 - Global problems and remedies to tackle pollution types.
- d. Human population and social issues.
 - Causes and remedy to population growth and control measures.
 - Social causes sex ratio, female infanticide, education of women affecting society.
 - Public health and awareness.
 - Role of information technology in environment and human sustenance.

Section B

Theoretical approaches to contemporary global management issues.

- a. Energy security, food scarcity, global demographics, international aid relief, conflict resolution, global business, climate change, microfinance, globalization, regional blocs, environment management, development, regeneration program, and reform of the United Nations and other international organizations.
- b. Triple concept of flows: flows of people (from international work migrants and asylum seekers to tourists and backpackers), flows of goods and capital (e.g. international trade, both in its legal and illegal dimension) and flow of information (with focus on digitalized information because of the major role of the internet). The study of flows will have perspective of sociology, human geography and international political economy and subsequent counter – flows, notably in terms of reactions, barriers, barriers and impacts.
- c. International development including, economic development policy, regional development and policy, demographics and development, human geography of global change, microfinance, health and environmental management, community responses; public health and international development; institutional governance; poverty and inequality and the concerns and aspirations of the UN (Millennium Development Goals).

Section C.

- a. Contemporary design scenario.
- b. Role of design and designer in society.

Learning Outcomes:

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

- Appreciate Environmental issues and its impact on the world.

- Understand the role of International agencies like United Nations, IMF, World bank in addressing the Global issues and finding the solution.
- Understand the role of contemporary design in addressing the contemporary global issue

Recommended Books:

1. Rana, S. V. S. (2004). *Environmental Studies*, Rastogi Publication, Meerut.
Bharucha, E. (2005) *Environmental Studies*. University Press. Hyderabad.

Development Economics and Environment

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

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

- Acquire a basic understanding of the issues and on-going debates on development economics.
- Discuss the important theories in economic development and their policy implication.
- Demonstrate a basic knowledge of the role of market and market failure with regard to the allocation of natural resources and environmental amenities.
- Analyze and interpret the environmental implications of economic decisions
- Understand the nature and scope of contemporary environmental debates

Unit 1 Meaning of Economic Growth and Development. Measures of Economic Development. Characteristics of Underdeveloped Economies. Obstacles to Economic Development.

Unit 2 Factors helping Economic Development; Natural Resources, Population, Human Capital, Physical Capital and Technology.

Unit 3 Characteristics of Modern Economic Growth. Theories of Economic Growth: Rostow's Stage Theory, Balanced and Unbalanced Growth.

Unit 4 Theory of Big Push, Critical Minimum Effort Theory, Nelson's Low-level Equilibrium Trap Theory.

Unit 5 Interrelationship between environment and economic development. Sustainable development – Concepts, Indicators and Measurement. Global environmental issues - The Global concern, Policy options in developing and developed countries.

Recommended Books:

1. Goel, R.L. (1975). *Economics of Growth and Development*. New Delhi: MeenakshiPrakashan.
2. Jhingan, M. L. (1974). *Economics of Development and Planning*. New Delhi: Vikas Publishing House.
3. Todaro, M. P. (1969). *Economic Development in the Third World*. New York: Longman Inc.
4. Mishra, S. K., & V. K. Puri (2010). *Economics of Development and Planning-Theory and Practice*. New Delhi: Himalaya Publication House.
5. Thirlwall, A.P. (2005). *Growth and Developmen*. New York: Palgrave McMillan.
6. सिन्हा, वी. सी. एवं दुबे, आर.एन. : आर्थिक विकास एवं नियोजन

E- Learning Materials:

1. <https://www.iisd.org/library>
2. [http://projekty.osu.cz/igeography/docs/Euromodel ENVIRONMENT%20AND%20DEVELOPMENT.pdf](http://projekty.osu.cz/igeography/docs/Euromodel%20ENVIRONMENT%20AND%20DEVELOPMENT.pdf)
3. <http://www.globalissues.org/issue/168/environmental-issues>
4. <https://www.ukessays.com/essays/economics/barriers-indias-economic-development-3066.php>

Biodiversity and Conservation

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

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

- Explain importance of biological diversity.
- Describe major threats to biodiversity.
- Recognize and implement the various methods of biodiversity conservation with co-existence of various environmental pressures.
- Identify different geographical biodiversity hotspots and mega-diversity centers.

Section A

- Introduction to biodiversity concepts, significance, magnitude and distribution.
- Biodiversity trends, diversity gradients and related hypotheses methods for monitoring biodiversity trends.
- Threats to biodiversity, major causes, extinction's, vulnerability of species to extinction, IUCN threat categories, Red data book.

Section B

- Principles of biodiversity conservation Ex situ and In situ methods of conservation, Genetical and evolutionary principles in conservation. Conservation of biological diversity and its significance- source of food, medicine, raw material, aesthetic, cultural and ecosystem services.
- Concepts, distribution and importance of Hot spots.
- Strategies for sustainable exploitation of biodiversity.

Section C

- Conservation – efforts in India, Endangered flora & fauna of India.
- Ethno botany in India & selected medicinal plants.
- Wildlife conservation in India- Project Tiger, Project crocodile, silent valley controversy.
- Conservation of Himalayan, Gangetic ecosystems.

Suggested Books:

- Kumar, U. &Asija, M.J. (2007). *Biodiversity – Principles and Conservation* (2nd ed.). Jodhpur, India: Agrobios.
- Mishra, R. (1968). *Ecology Workbook* (2nd ed.). Calcutta, India: Oxford and IBH.
- Odum, E.P. (1983). *Basic Ecology* (2nd ed.). Philadelphia,PA: Holt-Saunders International.
- Odum, E.P. (2004). *Fundamentals of Ecology*. Dehradun, India: Natraj.
- Singh, M.P., Singh, J.K., Mohanka, R., &Sah, R.B. (2007). *Forest Environment and Biodiversity* (2nded.). New Delhi, India: Daya.
- Sinha, B.N. (1990). *Ecosystem Degradation in India*. New Delhi, India: Ashish.
- Tewari, D.N. (1994) *Biodiversity and Forest Genetic Resources*. Dehradun, India: International Book.

Suggested e-resources:

- **Aquatic Biodiversity and Environmental Pollution, IISc, Bangalore**

<https://nptel.ac.in/courses/120108002/16>

➤ **Wildlife Conservation, Indira Gandhi National Forest Academy, Dehradun**

https://nptel.ac.in/noc/individual_course.php?id=noc18-bt26

Ecological Intelligence

Max. Marks : 100
(ESA: 100)

L	T	P	C
0	0	0	2

Learning Outcomes:

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

- Demonstrate a competency to respond to a design brief and develop critical thinking skills in analyzing environmental projects and scenarios within the context of ecological intelligence.
- Discuss application of ecological intelligence.
- Develop 'Green Infrastructure' principles from historic, theoretical and case studies and the relationship of Ecological Intelligence
- Demonstrate a competency to articulate, communicate and critically evaluate design intentions, applications and outcomes using a variety of technologies and techniques.

Course Contents

This course is designed to understand the concept and practice of Ecological Intelligence that constant interplay of consciousness, embodied experience within different cultural and environmental contexts. Ecological Intelligence examines the profound environmental, social, and health consequences of our everyday choices. This course introduces the core principles of modern thoughts and Decision making cycle for Environment and the hidden Price of What We Buy. This course includes the boundary lines that separate such fields of study as cultural linguistics, the sociology of knowledge, phenomenology, political economy, ecologically-oriented cultures, community development, intellectual and economic history—all of which have something to contribute to understanding both the nature of ecological intelligence and why it has not been valued by educated communities.

Recommended Books:

1. Goleman, D. (2010). *Ecological Intelligence: The Coming Age of Radical Transparency*. Penguin UK.
2. Goleman, D., Bennett, L. & Barlow, Z. (2012). *Eco literate: How Educators Are Cultivating Emotional, Social, and Ecological Intelligence*. Jossey-Bass.

Suggested E-learning Material:

1. http://arts.brighton.ac.uk/__data/assets/pdf_file/0018/5922/Ecological-Intelligence2.pdf
2. <http://www.cabowers.net/pdf/Book%20on%20E-Intell.doc>
3. <http://ijsse.com/sites/default/files/issues/2016/v6i2/Paper-09.pdf>
4. https://www.ecoliteracy.org/sites/default/files/uploads/shared_files/Ecological_Intelligence_teacher_guide.pdf

Ecology and Environment

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

After the completion of this course, students will be able to:

- Describe the interaction of organisms with their environment.
- Identify the various threats to biodiversity.
- Explain the concept of biomes.
- Describe the various biogeochemical cycles.

Course Content:

Section A

Introduction to Environment:

Concept of Environment, Factors of the environment: Physiographic, Climatic, Edaphic, Biotic and Anthropogenic. Bio Geochemical Cycles: The Carbon cycle, the Oxygen cycle, the Nitrogen cycle, The Hydrological cycle.

Section B

Concept of Ecology, Ecosystem and Biomes:

Concept of Ecosystem: With special reference to desert, forest and aquatic ecosystem. Food chain, Food web & succession. Ecological Pyramids and their types. Energy flow in ecosystem, Concepts of Biomes. Major biomes of the world: Tropical forest, temperate forest, Grassland and Tundra.

Section C

Environmental Pollution and its Effect

Environmental pollution: Pollutants and sources: Water pollution, Soil pollution, Air pollution and Noise pollution. Greenhouse Effect, Global warming, Biodiversity: Threats and Conservation.

Recommended Books:

1. Atkinson, Raw, M. (2007). *Biogeography*. Philip Allan Updates.
2. Gautam, A. (2007). *Environmental Geography*. Allahabad, India: Sharda Pustak Bhawan.
3. Huggett, R. J. (1998). *Fundamental of Biogeography*. London, UK:Routledge.
4. Kayastha, S.L., & Kumra, V.K. (1986). *Environmental Studies*. Varanasi, India: Tara Book Agency.
5. Mathur, H.S. (1998). *Essentials of Biogeography*. Jaipur, India: Pointer.
6. Mehtani, S., & Sinha, A. (2010). *Biogeography*. Commonwealth.
7. Odum, E. P. (1975). *Ecology*. Lanham, MD:Rowman and Littlefield.
8. Odum, E.P. (1968).*Fundamentals of Ecology*. London, UK:W.B. Sanders Company
9. Saxena, H. M. (1999). *Environmental Geography*. Jaipur, India:Rawat.
10. Saxena, H. M. (2000). *Environmental Management*. Jaipur, India:Rawat.

Suggested e-learning materials:

1. Environment and Ecology
<https://nptel.ac.in/courses/122102006/16>
2. Ecology and Environment
<https://swayam.gov.in/courses/4905-july-2018-ecology-and-environment>

Economic and Resource Geography

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
5	0	0	5

Learning Outcomes:

After the completion of this course, students should be able to:

- Describe and develop the approaches to economic and resource geography.
- Describe the resource related issues, map them systematically.
- Explain the interference of world trading blocs in international economics.
- Describe the non-conventional resources and their usability and apprise public about the depletion of resources.

Course Content:

Section A

Economic Geography: An Introduction

Definition and scope of Economic Geography, Approaches to the study of Economic Geography: Systematic, Regional, System Analysis, Behavioral, Welfare and Environmental; Sectors of Economy: Primary, Secondary, Tertiary and Quaternary; Factors affecting the location of economic activities; Trade: Evolution of International Trade, Factors affecting International trade, World Trading Blocs: NAFTA, EUROPEAN UNION, OPEC and SAARC.

Section B

Mineral and Energy Resources

Meaning and concept of resource; Classification of resources – on the basis of availability, distribution & frequency of occurrence and use of resources; Production and distribution of mineral resources: Iron ore and copper; Energy Resources: Conventional Resources; Coal: Uses of coal, Principal coalfields of the world, Production of coal in the world; Decline of coal in world fuel supplies; Petroleum: Origin and uses of Oil, Distribution of oilfields in the world, Production and Trade of Oil in the world, Petroleum Reserves and the future of the Oil industry; Non – Conventional Resources: Solar, Wind.

Section C

Industries and Locational Theories

History of Industrial Development; classification of industries; Location Theories: Weber and Losch; Iron and Steel Industry; changing location of the Iron and Steel Industry; Cotton Textile Industry: Distribution, Production and Trade in the world.

Stencils are to be permitted during the examination.

Recommended Books:

1. Gautam, A. (2010). *Advanced Economic Geography*. Allahabad, India: Sharda Pustak Bhawan.
2. Guha, J. L., & Chattoraj, P. R. (2009). *Economic geography – A Study of Resources* (9th ed.). Kolkata, India: The World Press.
3. Hartshorn, T. A., & Alexander, J. W. (2009). *Economic Geography* (8th ed.). New Delhi, India: Prentice Hall.

4. Leong, G. C., & Morgan, G. C. (2010). *Human and Economic Geography* (2nd ed.). New Delhi, India: Saurabh.
5. Siddharth, K. (2018). *Economic Geography* (3rd ed.). Allhabad, India: Kitab Mahal.
6. गौतम, ए. (2015). *आर्थिक भूगोल*. मेरठ, भारत: रस्तोगी.
7. जाट, बी. सी. (2016). *आर्थिक भूगोल* (चतुर्थ सं.). जयपुर, भारत: पंचशील.
8. मामोरिया, सी. (2012). *आर्थिक भूगोल* (द्वितीय सं.). आगरा, भारत: साहित्य भवन.
9. सिंह, के. (1978). *मानव और आर्थिक भूगोल* (द्वितीय सं.). वाराणसी, भारत: तारा.
10. सिंह, के. (2009). *आर्थिक भूगोल के मूलतत्व : संसाधन उपयोग, संरक्षण एवं आर्थिक विकास का अध्ययन* (11 वाँ सं.) वाराणसी, भारत: ज्ञानोदय.
11. सिंह, के. एन., एवं सिंह, जे. (2010). *आर्थिक भूगोल के मूलतत्व* (11 वाँ सं.). गोरखपुर, भारत: ज्ञानोदय.
12. सिंह, जे. (2009). *संसाधन भूगोल*. नई दिल्ली, भारत: राधा.

Suggested e-learning materials:

1. International trade
<https://gspp.berkeley.edu/assets/uploads/research/pdf/ssrn-id1783908.pdf>
2. NAFTA https://idatd.cepal.org/Normativas/TLCAN/Ingles/North_American_Free_Trade_Agreement-NAFTA.pdf

Economic Geography

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
6	0	0	6

Learning Outcomes: After the completion of the course, students will be able to:

- Define economic geography, describe its scope and relate it with other social sciences
- Classify resources and describe soil mineral and energy resources
- Describe spatial distribution, production and trade of rice, wheat, cotton, tea and Classify world into agricultural regions
- Describe several industries, their location determinants, and distribution of iron- steel and cotton-textile industry.
- Describe trade, transport, their controlling factors, major law making bodies of the world and major transport routes.

Course Content:

Unit I Definition and Scope of Economic Geography; Development of Economic Geography. Its relation with other Subjects; Concept of the Economy; Economic Activities: Primary, Secondary and Tertiary; Impact of Economic Activities on the Environment.

Unit II Natural Resources: Meaning and Classification of Resources; Conservation of Resources: Water & Forest; Soil Resources: Composition of Soil, Factors affecting soil formation; Soil profile, Soil classification (NRCS); Mineral Resource: Type, Distribution & Production of Iron Ore; Energy Resources: Types, Distribution and Production of Coal and Petroleum.

Unit III Agriculture: Physical and Socio– Cultural environment influencing crop production; Spatial Distribution, Production and International trade of Rice & Wheat; Spatial Distribution, Production and International trade of Cotton; Spatial Distribution, Production and International trade of Tea; Agricultural Classification: Whittlesey's Classification.

Unit IV Manufacturing Industry: Meaning & Types; Determinants of location of industry; Industrial Location Theory: A. Weber; Distribution & production of Iron & Steel industry; Distribution & Production of Cotton Textile Industry.

Unit V Trade: Type of trade, Factors affecting International trade; Evolution of International trade, Barriers of International trade, Agencies: GATT, WTO, EUROPEAN UNION; Transport: Importance & Development of transport; Means of transport; Water Transport: Suez Canal, Panama Canal, North Atlantic Route. Stencils are to be permitted during the examination.

Recommended Books:

1. Guha, J. L. & Chattoraj, P. R. (2009). *Economic geography – A Study of Resources* (9thed.). Kolkata, India: The World Press.
2. Gurjar, R. & Jat, B. C. (2010). *Resources and Environment* (7thed.). Jaipur, India: Panchsheel.
3. Hodder, B. W. & Lee, R. (2008). *Economic Geography* (Indian Reprint). Jaipur, India: Rawat.
4. Leong, G. C. & Morgan, G. C. (1982). *Human and Economic Geography* (2nd ed.). New York. NY: Oxford Press.
5. Maurya, S. D. (2018). *Economic Geography*. Allahabad, India: Pravalika.
6. Shelar, S. K. (2013). *Principles of Economic Geography*. Kanpur, India: Chandralok.
7. Siddhartha, K. (2006). *Economic Geography Theories, Processes and Patterns* (2nded.). Delhi, India: Kisalaya.
8. Siddhartha, K. (2016). *Economic Geography* (3rded.). Delhi, India: Kitab Mahal.
9. गौतम, ए. (2015). *आर्थिक भूगोल के मूल तत्त्व*. इलाहाबाद, भारत: शाखा पुस्तक भवन.

10. जाट, बी. सी. (2016). *आर्थिक भूगोल* (चतुर्थ सं.). जयपुर, भारत: पंचशील.
11. मामोरिया, सी. (2012). *आर्थिक भूगोल* (द्वितीय सं.). आगरा, भारत: साहित्य भवन.
12. राव. एस. (2013). *आर्थिक भूगोल*. गोरखपुर, भारत: वसुन्धरा.
13. सिंह, के. एन. एवं सिंह, जे. (2010). *आर्थिक भूगोल के मूलतत्व* (11वाँ सं.). गोरखपुर, भारत: ज्ञानोदय.
14. सिंह, जे. (2009). *संसाधन भूगोल*. नई दिल्ली, भारत: राधा.

Suggested e-learning materials:

1. Suez Canal trade route
<https://www.britannica.com/topic/Suez-Canal>
2. Panama Canal
<https://www.pancanal.com/eng/op/routes.html>

Economics of Environment

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
5	0	0	5

Learning Outcome:

After completion of the course, the student will be able to:

- Explain the meaning and scope of Environmental Economics.
- Conceptualize and explain ideas like externality and market failure
- Undertake Environmental Valuation using different techniques
- Explain the idea of Sustainable development
- Understand various practical environmental issues at national and global level
- Understand the role of global and national governments and organizations in resolving environmental issues.

Section- A

Meaning, importance and scope of environmental economics; The evolution and growth of environmental economics; Linkages between environment and economics; The concept of externalities, Environment as a public good and market failure; Environmental Kuznets's curve; Environmental valuation: Meaning and types of environmental valuation, Market valuation, Contingent Valuation Method (CVM), Hedonic pricing technique; Environmental accounting.

Section- B

Sustainable development: Concept, indicators, measurement and Strategies for sustainable development; Economics of natural resources: A resource taxonomy; Managing exhaustible and renewable resources; Methods of abatement of externalities: The Pigouvian tax – Subsidy approach; Cost-Benefits analysis to environmental analysis.

Section- C

Global environmental issues: Negative international externalities and their implications; Major environmental organization and events: Green peace movement, The World conservation union, the nature conservancy. Sierra club, UNEP, UNCED. The Vision, goals, objectives and instruments of environmental policy; A critique of India's environmental policy.

Recommended Books:

1. Bhattacharya, R.N. (ed.). (2001). *Environmental Economics: An Indian Perspective*, Oxford University Press, and New Delhi.
2. Bromely, D. W. (1995). *Handbook of Environmental Economics*. Blackwell.
3. Ch. Hanumantha Rao. (1994). *Agricultural Growth, Rural Poverty and Environmental Degradation in India*, Oxford University Press, New Delhi.
4. Dasgupta, P and Heal, G. M. (1979). *Economic Theory and Exhaustible Resources*, Cambridge University Press.
5. Dixon, J. (1994). *Economic Analysis of Environmental Impacts*, Earthscan Publications, London.
6. Field, B. C., (1994). *Environmental Economics: An Introduction*. McGraw Hill, New York.
7. Government of India. (1992). *Policy Statement for Abatement of Pollution, Ministry of Environment and Forests*. New Delhi.
8. Hanley, N, J. F. Shogren and B. White. (1997). *Environmental Economics in Theory and Practice*, MacMillan, New York.

9. Hardin, G. "The Tragedy of Commons", in Markandya, A. and Richardson, J. (eds.). (1993). *Earthscan Reader in Environmental Economics*. Earthscan Publications, London.
10. Jempa, C. and Munasinghe, M. (1998). *Climate Change Policy: Facts, Issues and Analyses*, Cambridge University Press.
11. Karpagam M. (1992). *Environmental Economics: A Text Book*. Sterling Publishers Pvt. Ltd. Green Park Ext. New Delhi.
12. Kolstad, Charles (2000). *Environmental Economics*, Oxford University Press.
13. Mehta, S., Mundle, S., and Sankar, U. (1997). *Incentives and Regulation for Pollution Control*. Sage Publication, New Delhi.
14. Murty, M. N., A. James and S. Misra. (1999). *The Economics of Water Pollution in India*, Oxford University Press, New Delhi.
15. Oates, W. E. (1992). *Economics of the Environment*, Edward Elgar, Cheltenham, U.K.
16. Opschoor, J. B. and Vos, H. B. (1989). *Economic Instruments for Environmental Protection*. OECD and OCDE.
17. Sankar, U., Mythili, G. and Anuradha, R. (1996). *Environmental Problems in India's Energy Sector and Policies for Corrective Action* (Project Report), Madras School of Economics, Chennai.
18. Sankar, U. (ed.). (2000). *Environmental Economics*, Oxford University Press.
19. United Nations ESCAP. (1997). *Accounting and Valuation of Environment, Vol. I and II: A Primer for Developing Countries*, New York.
20. World Bank. (1992) *Development and the Environment: World Development Report Series*, Washington, D. C.

E - Learning Material :

1. <https://www.nature.com/subjects/environmental-economics>
2. <https://www.cseindia.org/>
3. <https://www.niti.gov.in/>
4. <https://www.indiabudget.gov.in/index.as>
5. <https://www.epw.in/>

Agriculture Economics

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
5	0	0	5

Learning Outcome:

After completion of the course, the student will be able to:

- Understand basic concepts of Agriculture Production, Debate of Farm size and productivity.
- Analyse theories of Agriculture Development.
- Examine issues and problems of Agriculture Price Policy in India.
- Understand impact of WTO on Indian Agriculture
- Acquire adequate knowledge to assess the Food Policy of India.
- Understand issues of agriculture marketing.

Section-A

Role of Agriculture in Economic Development; Interdependence between Agriculture and Industry; Structural Problems in Agriculture; Tenancy and Crop Sharing- Land Reforms and Economic Development, Agricultural labour- Interlocking of Factor Markets. Theories of Agricultural Development – Schultz, Mellor, Hayami, Ranis-Fei. Institutions and Agricultural Models-Lenin and Kautsky.

Section-B

Agricultural Production and Productivity; Production Function Analysis in Agriculture. Farm Size and Productivity Debate; Theoretical and Empirical Findings. Green Revolution and its Impact on Production and Distribution, Agricultural Growth and its Regional Dimensions in India. WTO and Indian Agriculture. Food Security and International Trade- Concepts, Threat, Indicators and Mechanism to Food Security.

Section-C

Agricultural Price Policy and issues; Its Rationale, Instruments and Evaluations. Credit in Agriculture: Role and Sources, Cooperative Movement in India- Organisation, Structure and Development of Different Types of Cooperatives in India. Issues related to Investment and Subsidies in Indian Agriculture; Importance of Rural Infrastructures in Agricultural Development, Agriculture Marketing and e NAM, Food Security and Nutrition Security, Food Policy

1. Acharya, S. S., & Agrawal, N. L. (2009). Agricultural marketing in India “Oxford and IBH Publishing Co. Pvt. Ltd.
2. Bhalla, G. S., & Gurmail, S. (2001). Indian agriculture: four decades of development. Indian agriculture: four decades of development.
3. Bhalla, G. S. (2007). Indian agriculture since independence. Indian agriculture since independence.
4. Bharadwaj, K. (1985). A view on commercialization in Indian agriculture and the development of capitalism. The Journal of Peasant Studies, 12(4), 7-25.
5. Black, J. D. (1953). Introduction to economics for agriculture. The Macmillan Company: New York.
6. Chadha, G. K. (2004). Land Resources (Vol. 2). Academic Foundation.
7. Dhawan, B. D. (1988). Irrigation in India’s agricultural development: productivity, stability, equity (No. Sage Publications (Pvt) Ltd..
8. Griffin, K. (1979). The political economy of agrarian change: An essay on the Green Revolution. Springer.

9. Gulati, A., & Kelley, T. (1999). Trade liberalization and Indian agriculture: cropping pattern changes and efficiency gains in semi-arid tropics. Oxford University Press.
10. Kahlon, A. S. (1983). Agricultural price policy in India. South Asia Books.
11. Khusro, A. M. (1973). Economics of land reform and farm size in India.
12. Meier, G. M., & Rauch, J. E. (1995). Leading issues in economic development (Vol. 6). New York: OxfordUniversity Press.
13. Rao.C.H. (1975). Technological change and distribution of gains in Indian agriculture.
14. Rao, C. H. (1993). Agricultural growth and rural poverty in India: emerging trends and perspectives. Indian Economic Review, 129-140.
15. Planning Commission. (2015). Report of the Working Group on Agricultural Marketing Infrastructure,
16. Secondary Agriculture and Policy Required for Internal and External Trade for the Twelfth Five Year Plan (No. id: 6873).
17. Schultz, T. W. (1964). Transforming traditional agriculture. Transforming traditional agriculture.
18. Verma, N.M.P. (1990), Irrigation Change and Agricultural Development, Uppal, New Delhi.
19. Visarioa, B and R. Basant (1994), Non-Agricultural Employment in India, Trends and Prospects, Sage.
20. Wanmali S. and C. Ramasamy (Eds.) (1995). Developing Rural Infrastructure; Macmillan, New Delhi.

E- Learning Material

1. Agricultural Statistics at a Glance 2010, Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, New Delhi.
2. State of Indian Agriculture: 2012-13, Ministry of Agriculture, Government of India, New Delhi
3. <https://eands.dacnet.nic.in/>
4. <https://www.coursera.org/learn/agriculture-economics-nature>
5. <http://www.student.uwa.edu.au/faculties/faculty-of-science/Agriculture-and-Envrionment-students/courses/online>
6. http://agriculture.gov.in/Admin_MOAFW/Data/February2018.pdf

Advanced Economic Geography

LT PC

4 0 0 4

Max. Marks : 100

(CA: 40 + ESA: 60)

1. Concept of Economic Geography, nature and pattern of economic activities: primary, secondary and tertiary activities.
2. Recent themes and concepts in Economic Geography,
3. Concept of economic resource, Resource evaluation, Resource planning and management
4. Economic Development: Theories and Measures of economic development.
5. Theories of Industrial Location and Localization(Weber, Hoover, Losch, Pred), Industrial Regions of the World and India,
6. World Trade Organization, Globalization and its impact on World Economy.
7. Agricultural land use and cropping pattern, measures of Agricultural efficiency, crop combination regions (J. C. Weaver and K. K. Doi).
8. Concept of location of Agricultural activities, Agricultural typology, changing cropping pattern.
9. Modern concepts in Agriculture Geography: sustainable development, agribusiness, contract farming, dry land farming, cropping systems.

Books Recommended:

1. Clark, G. L., Feldman, M.P. and Gertler, M.S. (eds.) (2000): The Oxford Handbook of Economic Geography. Oxford University Press, Oxford and New York.
2. Conking, E. C. and Yeates, M. (1996) "Man's Economic Environment" McGraw – Hill Book Company.
3. Freeman, T. W. (1972): Geography and Planning. Freeman and Company, New York.
4. Friedman, J. and Alonso, W. (1964) Regional Development and Planning: A Reader, The M. I. T.
5. Gautam, Alka, (2010), Advanced Economic Geography, Sharda Pustak Bhawan, Allahabad
6. Guha, J.L. and P.R.Chatturaj (1994) Economic geography- A Study of Resources, The World Press Pvt. Ltd. Calcutta
7. Gupta, P and Sadasyuk, G. (1968): Economic Regionalization of India: Problems and Prospects. Census of India, New Delhi
8. Hanif M. (2005): Encyclopedia of Agriculture Geography, Anmol Publications PVT Ltd.
9. Hartshorn, T. A. and Alexander, J. W. (1988) 'Economic Geography', Prentice Hall, New Delhi.
10. Leong, Gon Cheng & Morgan, Gilliam C.: (1973) Human and Economic Geography, Oxford University Press.
11. Ramesh, A. (ed.) (1984): Resource Geography. Heritage Publishers, New Delhi.
12. Shafi Mohammed (2000): Agricultural Geography of South Asia., MacMillan Publishers India
13. Siddharth, K. (2006) Economic Geography, Kisalaya Publications, New Delhi. Singh & Dhillon (2004): Agriculture Geography (3rd Edition), Tata McGraw – Hill.
14. Singh, R.L. (Ed.): (1966) Applied Geography, BHU press, Varanasi.
15. Wheeler J. O. Mullar, O. M. Thrall, G. I. and Timothy, J. F. (1988) "Economic Geography", John Wiley and Sons Inc. New York.
16. कुमार, प्रमीला एवं शर्मा, श्री कमल (2008) कृषि भूगोल, मध्य प्रदेश हिन्दी ग्रन्थ अकादमी, भोपाल।
17. जाट, बी. सी. (2006) आर्थिक भूगोल, पंचशील प्रकाशन, जयपुर।
18. हुसैन, माजिद (2000) कृषि भूगोल, रावत पब्लिकेशन, जयपुर।
19. मामोरिया, चतुर्भुज (2008) आर्थिक भूगोल, साहित्य भवन पब्लिकेशन, आगरा।
20. एस. डी. कौशिक एवंम डॉ. अल्का गोतम (2011) संसाधन भूगोल, रस्तोगी एण्ड रस्तोगी पब्लिकेशन।
21. शर्मा, हरिश्चंद्र, (1983) भारत का आर्थिक भूगोल तथा भारतीय अर्थशास्त्र, रमेश बुक डिपो, जयपुर।
22. सिंह जे. (2009) संसाधन भूगोल, राधा पब्लिकेशन, नई दिल्ली।
23. सिंह के. एन., और सिंह जे. (2003) आर्थिक भूगोल के मूल तत्व, ज्ञानोदय प्रकाशन, गोरखपुर।

24. सिंह, काशीनाथ (2009) आर्थिक भूगोल के मूल तत्व : संसाधन उपयोग, संरक्षण एवं आर्थिक विकास का अध्ययन, ज्ञानोदय प्रकाशन।
25. सिंह, काशीनाथ (2009) आर्थिक भूगोल के मूल तत्व : संसाधन उपयोग, संरक्षण एवं आर्थिक विकास का अध्ययन, ज्ञानोदय प्रकाशन, गोरखपुर।

Sustainable Environments

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
2	0	0	2

Theory

Section A

- Definition of green building, and sustainable and eco-friendly design,
- Global environmental issues as per UN charter.
- Global concern, policy options in developing and developed countries.

Section B

- Inclusive manufacturing its meaning and scope.
- Sustainable and inclusive manufacturing concepts, implementations and concern

Section C

- Science of Acoustics
- Behavior of sound in enclosed space.
- Understanding acoustics and its integration with sound absorbent.
- Thermal Comfort - heat flow, thermal properties of material, human response to thermal environment.
- Comfort vs functionality.

Learning Outcomes:

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

- Understand and learn to utilize material in a sustainable manner.
- Understand the parameters required to be considered during the designing of any sustainable projects.

Recommended Books

1. Chan, Yenna. (2007). *Contemporary Design in Detail: Sustainable Environments*. Rockport.
2. Mobbs, Michael. (2005). *Sustainable House Living for Our Future*. Choice Books,
3. *Winning Strategies for a Sustainable Future Reinhard Mohn Prize 2013*. Bertelsmann Stiftung, 2013
4. Fulekar, m. H. (2016). *Environment and sustainable development*. Springer, India, private.

Political Geography

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
5	0	0	5

Learning Outcomes:

After the completion of this course, students should be able to:

- Develop an approach to study political geography.
- Describe growth of the states and concept of Geopolitics.
- Differentiate between state and nation and also explain geopolitical issues with special reference to Sino India and Indo Pak.
- Discuss world political and environmental issues.

Course Content:

Section A

Introduction to Political Geography and Geopolitics

Definition and scope of political geography; Approaches to the study of Political Geography – Political-Environmental approach, Power analysis approach, Functional approach and A unified Field Theory; Laws of Spatial Growth of states; Concept of Geopolitics.

Section B

Concept of States and Nation

States and Nation: A historical perspective; The elements of a State and difference between Nation and State; Concept and classification of Frontiers and Boundaries; Buffer states: Nepal and Bhutan; Concept of core areas.

Section C

Global Strategies and International Problems

Geo Strategic Hypothesis-Theory of Heartland and Rimland; The round world perspective: Global strategies in Air age; Concept of Federalism and Politico- Geographic factor in rise of Indian federalism; International problems related with boundaries: Sino-India and India- Pakistan border; Environmental problems and world politics

Stencils are to be permitted during the examination.

Recommended Books:

1. Blacksell, M. (2005). *Political Geography*. London, UK: Routledge.
2. Chopra, G. (2006). *Political Geography*. New Delhi, India: Commonwealth.
3. Dixit, R. D. (2006). *Political geography, the Spatiality of Politics*. New Delhi, India: Tata McGraw-Hill.
4. Flint, C., & Taylor, P. J. (2018). *Political Geography: World-economy, nation-state, and locality* (6th ed.). New Jersey, NJ: Pearson/Prentice Hall.
5. Gallaher, C., Dahlman, C. T., Gilmartin, M., & Mountz, A. (2012). *Key Concept in Political Geography*. California, CA: Sage.

6. Jones, R., Woods., Michael., & Jones., M. (2009). *An Introduction to Political Geography: Space, Place and Politics*. Abingdon, UK: Routledge.
7. Painter., Joe., Jeffrey., & Alex (2010). *Political Geography* (2nd ed.). California, CA: Sage.
8. Singh, I. (2006). *Political Geography*. New Delhi, India: Alfa.
9. Sukhwal, B. L. (1971). *India-A Political Geography*. New Delhi, India: Allied.
10. चौहान, पी. आर. (2010). *राजनीतिक भूगोल*. गोरखपुर, भारत: वसुब्धरा.
11. तिवारी, आर. सी. (2017). *राजनीतिक भूगोल*. इलाहाबाद, भारत: प्रवालिका.
12. सक्सेना, एच. (2010). *राजनीतिक भूगोल* (पंचम् सं.).मेरठ, भारत: रस्तोगी.

Suggested e-learning materials:

1. Geopolitics
[https://www.newworldencyclopedia.org/entry/Indo-pakistani Wars](https://www.newworldencyclopedia.org/entry/Indo-pakistani_Wars)
2. International problems related with boundaries: India- Pakistan border
[http://www.newworldencyclopedia.org/entry/Indo-Pakistani Wars](http://www.newworldencyclopedia.org/entry/Indo-Pakistani_Wars)

Public International Law

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	1	0	5

Learning Outcomes:

- The students will be able to get indepth knowledge of Public International Law.
- The students will be able pursue careers in government agencies, international organisations, non-governmental organisation and the private law firms which are dealing in global legal issues.
- The students will be able get theoretical knowledge and handle the complexity of drafting of various instruments which encouraged them to think creatively about the challenges within the Public International law.
- The students will able to understand a system regulating interstate interactions.

Note: The paper will contain ten questions having at least two questions from each unit. Candidates are required to attempt five questions in all taking at least one question from each unit.

Unit I Introduction: Definition, Development, Nature, Binding-force, Subjects, Basis and Codification of International Law, Customary and Modern International Law, Relationship between International Law and Municipal Law, Distinction between Public and Private International Law and Sources of International Law.

Unit II Recognition in International Law: Concept, kind and Theories, Legal Consequences

State Succession: Definition and kind of Succession, Consequences of State Succession

State Jurisdiction: Principles of Civil and Criminal Jurisdiction, Jurisdictional Immunities to Heads of States and Diplomatic Agents, Extradition and Asylum.

The Law of Treaties: Definition, Binding-Force, Making of Treaties, Reservations, Amendments and, Termination of Treaty and Unequal Treaty

Unit III The law of warfare: War, Total War, Effects of War, Efforts to ban war, War Crimes, Enemy character, Law of War: International Humanitarian Law – Law of Land, Naval and Aerial Warfare, International Criminal Court, Efforts towards control of Nuclear Weapons, Belligerent Occupation, Neutrality, Rights and duties of belligerents and neutral states, Blockade, Contraband of War, Doctrine of Continuous Voyage, prize courts, right of Angry, International Terrorism and Counter Terrorism.

Unit IV International Organizations: The League of Nations, Defects, The UNO – Origin, UN Charter, Amendment of The Charter, the General Assembly – Composition, Voting Right and Contribution, Security Council – Composition, Veto, Double Veto, Contribution in settlement of Disputes, Collective Security, Uniting for Peace Resolution, ECOSOC, Trusteeship Council, Secretariat and ICJ – Composition, the Statute of the ICJ, Role in the Settlement of Disputes and in the Development of International Law, Contribution of the UN on International Level.

Unit V Specialized agencies of the UN – ILO, WHO, UNESCO, IBRD, IMF AND WIPO – Origin, Functions and Contribution, The Role of International Financial Institutions in Globalization.

International Responsibility of States: Kinds of State Responsibility, Consequence of State Responsibility.

Leading Cases:-

1. UK v/s Albania, 1949 ICJ Rep4. (Corfu Channel Case)

2. Nicaragua v/s USA, 1986 ICJ Rep 14 (Military & Paramilitary Activities against Nicaragua case)
3. Columbia v/s Peru, 1950 ICJ Rep 266. (Asylum case)
4. Federal Republic of Germany v/s Denmark & Netherlands, 1969 ICJ Rep 3. (North Sea Continental Shelf case)
5. UK v/s Norway, 1951 ICJ Rep 116. (Anglo Norwegian Fisheries case)
6. France v/s Turkey, (1927) PCIJ Ser. A, No. 10, 4. (S.S. Lotus case)
7. Liechtenstein v/s Guatemala, 1955 ICJ Rep 4. (Nottebohm case)
8. Corfu Channel Case, ICJ Rep. (1949)
9. Kutch Arbitration Award, 1968
10. Shimoda Case, 1963
11. Zamora Case, 1916 AC 77
12. Nuremberg Trial, 1946
13. Tokyo Trial, 1946
14. Aerial Incident (Israel v/s Bulgaria) TCJ Rep. 1959
15. Shooting down of Pakistani Aircraft by India during Kargil war, 1999
16. Terrorists attack on America's WTC, 2001
17. Pakistani terrorist attack on Indian Parliament, 2001

Suggested Readings:

1. Kapoor, S.K. (2011). *International Law* (15th ed.). Allahabad: Central Law Agency.
2. Tandon, M.P. (2017). *Public International Law* Allahabad: Central Law Agency.
3. Shearer, I. A. (2011). *Starke's International Law* New Delhi: Oxford University Press.
4. Stone, J. (1959). *Legal Controls of International Conflicts* US: Rinehart.
5. Jennings, R. (1993). *Oppenheim's International Law* Vol. I Parts I & II. New Jersey: Law Book Exchange LTD
6. Kelsen, H. (2011). *The Charter of the United Nations* New Jersey: Law Book Exchange Ltd.

Suggested E-Learning Material:

1. Karamanian S.L. Public International Law versus Private International Law: Reconsidering the Distinction Retrieved from http://www.oas.org/es/sla/ddi/docs/publicaciones_digital_XL_curso_derecho_internacional_2013_Susan_L_Karamanian.pdf
2. Argent P. D. Lecture on International Law. Retrieved from <https://www.youtube.com/watch?v=euwsKG5MyqM>
3. Kashyap Aprajita. Lecture on International Organization. Retrieved from <https://www.youtube.com/watch?v=lv3Z4VAvboM>

Note : Students will be required to opt one course from the list of Discipline electives.

Technical Textiles and Textile Ecology

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

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

- Understand meaning, classification and application of technical textiles
- Explain effect of industrial pollution on health and environment
- Know red listed chemicals, allergic dyes, carcinogenic amines and harmful dyes
- Describe eco parameters and eco friendly textiles
- Understand treatment and disposal of textiles effluent and dyes

Syllabus :

Section A

1. Technical textiles – meaning, classification, application of technical textiles, manufacturing techniques, future scenario
2. Medical textiles, agro textiles, geo textiles, industrial textiles automotive textiles, phase change materials, shape memory materials, smart textiles

Section B

1. Effect of industrial pollution on health and environment, allergic dyes, carcinogenic amines, harmful dyes, red listed chemicals as per eco classification
2. German ban, Indian ban, banned dyes
3. Eco-parameters, eco-friendly textiles
4. International legislation and environmental standards, eco-mark and eco-label

Section C

1. Treatment and disposal of textiles effluent and dyes
2. Ecofriendly production and processing of textiles
3. Testing of textiles and auxiliaries, testing facilities, Govt. and private labs

References:

1. Horrocks, A.R. (2008). *Handbook of Technical Textiles*. Florida: CRC Press.
2. Mirraftab, M. and Horrocks, A.R. (2007). *Eco-textiles: The way forward for sustainable development in textiles*. Florida: CRC Press.
3. Slater, K. (2003). *Environment Impact of Textiles: Production, Process and Protection*. Florida: CRC Press.

E-Resources:

- Classification and application of technical textiles,
<http://textilelearner.blogspot.com/2012/09/classification-and-applications-of.html>
- Properties, application and uses of technical textiles,
http://www.t-pot.eu/docs/Workshops/LEITAT_5_Technical_Textiles_1.pdf
- Textile effluent treatment- slide share,
<https://www.slideshare.net/GranchBerheTseghai/textile-effluent-treatment>

Environmental Toxicology

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

After the completion of this course, students will be able to:

- Recognize dangerous toxic compounds and what properties make them toxic.
- Discuss the toxicological concepts of different toxic substances.
- Predict the transport and fate of toxicants in environment.
- Assess the effect of toxic substances on the environment health.

Course Content:

Section A

Principles in toxicology; Definition of Xenobiotics. Concepts of LD50; Dose-effect and dose-response relationship.

Biological and chemical factors that influence toxicity; Bio-transformation and bio-accumulation.

Eco-system influence on the fate and transport of toxicants

Abiotic Stress response in living systems.

Section B

Origin of pollutants: industrial, agricultural, domestic and vehicular sources. Pollutant & their toxicology: Heavy metals (Pb and Cr) and trace elements. agrochemicals (Pesticides, herbicides, & fungicides, detergents) & particulate matter.

Global dispersion of toxic substance

Types of radiations including ionizing & non-ionizing radiations & their interaction with matter.

Section C

Radiations as environmental pollutants. Effects of radiations at cellular, molecular & genetic level, Mutagenesis. Carcinogenicity.

Recommended Books:

1. Ahmad, P., & Prasad, M. N. V. (2012). *Abiotic Stress Responses in Plants: Metabolism, Productivity and Sustainability*. New York, NY: Springer-Verlag.
2. Ahmad, P., Ahanger, M.A., Singh, V.P., Tripathi, D.K., Alam, P., & Alyemeni, M.N. (2018). *Plant Metabolites and Regulation under Environmental Stress*. Massachusetts, MA : Academic Press.
3. Cockerham, L.G., & Shane, B.S. (1993). *Basic Environmental Toxicology*. Florida, FL: CRC Press.
4. Gaur, R.K., & Sharma, P. (2013). *Molecular Approaches in Plant Abiotic Stress*. Florida, FL: CRC Press.
5. Gaur, R.K., & Sharma, P. (2014). *Approaches to Plant Stress and their Management*. New Delhi, India: Springer.

6. Newman, M.C. (2014). *Fundamentals of Ecotoxicology: The Science of Pollution* 4thed.). Florida, FL: CRC Press.

Suggested e-learning materials:

1. Environmental Toxicology
<https://nptel.ac.in/courses/120108002/>
2. Toxicological Chemistry
<https://nptel.ac.in/courses/122106030/>

Environmental and Fuel Lab

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
0	0	4	2

Learning Outcomes:

The students will be able to:

- Determine different parameters associated with fuel analysis
- Evaluate pollutants quality
- Do sample collection and analysis of data to assess the environmental impact

Environmental Pollution Control

1. pH and TDS measurement for water samples
2. Available chlorine
3. COD measurement
4. BOD measurement
5. DO measurement through aeration unit
6. Air pollution measurement
7. Noise pollution measurement

Fuel Analysis

8. Coal sample analysis
9. Bomb calorimeter
10. Carbon residue
11. Smoke point analysis
12. Flash point measurement
13. Orsat gas analysis
14. Reid vapor pressure

Note: Minimum five experiments from each subject are compulsory.

Energy Auditing and Conservation

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

After the completion of this course, students will be able to:

- Describe Energy audits for building.
- Describe energy conservation measures.
- Explain energy efficient lighting technologies and its application in commercial and residential sectors.
- Describe Energy storage technologies and Energy Auditing.

Course Content:

Section A

Barriers to energy conservation, Key energy issues to 2025, Carbon dioxide emission, Energy Audits for building (Background, Energy Audit Procedures, Energy Management Programs & Energy Conservation Measures).Electrical Energy Management in Buildings (Principal Electricity Uses in Building, Strategies for Electricity End-Use Management), Heating, Ventilating and Air-Conditioning Control Systems (Modes of Feedback Control, Basic Control Hardware, Basic Control Systems Design Considerations & Example of HVAC Control Systems).Energy Efficient Lighting Technologies and Their Applications in the Commercial And Residential Sectors (Design of Energy-Efficient Lighting Systems, Lighting Technologies, Efficient Lighting Operation, Current Lighting Markets and Trends

Section B

Energy Efficient Technologies: Major Appliances and Space Conditioning Equipment (Description of Major Appliances and Space Conditioning Equipment, Current Production & Efficient Designs), Heat Pumps (Basic Principles, Solar-Assisted Heat Pump Systems & Geothermal Heat Pumps). Industrial Energy Efficiency and Energy Management (Energy Efficiency and Energy Management Improvement, Improving Energy Audits, Electricity End Uses and Electrical Energy Management).

Section C

Electric Motor System Efficiency (Motor System Efficiency & Energy Saving Applications). Energy Storage Technologies (Overview of Storage Technologies, Principal Forms of Stored Energy, Applications of Energy Storage, Specifying Energy Storage Devices, Specifying Fuels, Energy Storage: Direct Electric, Electrochemical, Mechanical, Direct Thermal & Thermochemical).

Recommended Books:

1. Abbi, Y.P., & Jain S. (2006). *Handbook on Energy Audit and Environment Management*. Delhi, India: TERI Press.
2. Goswami, D. Y., & Frank K. (2015). *Energy Efficiency & Renewable Energy Handbook*. Florida,FL: CRC Press (Taylor & Francis Group).
3. Polimeros, G., (1981). *Energy Cogeneration Handbook*. New York, NY: Industrial Press.

4. Threlkeld, L. (1970): *Thermal Environmental Engineering* (2nd Ed.). New Jersey, NJ: Prentice Hall.
5. Trinks, W., Mawhinney, M. H., Shannon, R. A. & Reed, R. J., & Garvey J. R. (2003). *Industrial Furnaces* (6thed.). New Jersey, NJ: John Wiley & Sons.
6. Turner, W. C. (2007). *Energy Management Handbook* (7thed.). Georgia, USA: Fairmont Press.
7. Witte, L. C., Schmidt, P. S., & Brown, D. R. (1998). *Industrial Energy Management and Utilization*. Washington, WA: Hemisphere.

Suggested e-learning materials:

1. [Energy Efficiency, Acoustics and daylighting in Building](https://onlinecourses.nptel.ac.in/noc18_ce06/preview),
[https://onlinecourses.nptel.ac.in/noc18_ce06/preview\](https://onlinecourses.nptel.ac.in/noc18_ce06/preview)
2. Environment Management
<https://nptel.ac.in/courses/120108004/module9/lecture12.pdf>
3. Energy Audit
<https://ecozensolutions.com/audit.pdf>
4. Energy Management and Audit <https://beeindia.gov.in/sites/default/files/1Ch3.pdf>
5. Energy Conservation and waste heat recovery <https://nptel.ac.in/courses/112105221>

Environmental Biology and Toxicology

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

After successful completion of the course, students should be able to:

- Identify key factors responsible for ecosystem balance.
- Comprehend the toxicity of various environmental pollutants and their influence on ecosystem.
- Explain different efforts which can be undertaken for restoration and environmental remediation.

Section-A

Concept of energy, conventional & non-conventional energy sources. Fossil fuels, hydropower, wind power, nuclear power, geothermal, solar and bioenergy.

Energy flow in organisms, Energy pathways & models, energy efficiencies, conservation of energy.

Classification & Characteristics of resources: water, soil, forest, wildlife, land.

Conservation of natural resources - water, soil, forest and wild life.

Section-B

Origin of pollutants-industrial, agricultural, domestic and vehicular sources.

Pollutant & their toxicology-Heavy metals and trace elements. Agrochemicals (Pesticides, herbicides, rodenticides & fungicides), detergents & particulate matter.

Types of radiations including ionizing & non-ionizing radiations & their interaction with matter.

Radiations as environmental pollutants.

Effects of radiations at cellular, molecular & genetic level.

Section-C

Mutagenicity, carcinogenicity.

Green house effect, acid rains.

Ozone layer depletion, photochemical smog.

Types of solid wastes, transport, reuse & recycling.

Books recommended:

- Encyclopedia of pollution & its control: Vol. I-VI
- Environmental Biology and Toxicology: P. D. Sharma
- Environmental Impact Assessment: Clark, Bissel & Watham.
- Field Biology and Ecology: R.L. Smith.
- Fundamentals of Ecology: Eugene P. Odum.

Introduction to Toxicology: J.A. Timberell.

Environmental Biology and Biotechnology

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

After successful completion of the course, students should be able to:

- Identify key factors responsible for ecosystem balance and explain different efforts which can be undertaken for restoration and environmental remediation.
- Comprehend the toxicity of various environmental pollutants and their influence on ecosystem.
- Understand different waste management processes and generation of energy from waste.
- Describe various roles played by microbes in biodegradation, bioremediation and plant growth promotion.

Section A

- Structure and functions of ecosystem.
- Energy flow in organisms, energy pathways & models, energy efficiencies.
- Basic concept of Population Ecology–Inter & intra-specific interactions among populations.
- Community structure & dynamics: Ecological succession.
- Natural resources & conservation: water, soil, forest, wild life.
- Environmental challenges & sustainable development; Environmental Laws & Acts.

Section B

- Heavy metal toxicity, agrochemical pollutants:
Bioremediation of heavy metal pollution and oil spills, phytoremediation.
- Radiations as environmental pollutants. Effects of radiations at cellular, molecular & genetic level. Disposal of radioactive waste.
- Waste water treatment- sources of waste water, strategies used in primary, secondary & tertiary treatments, water reclamation.

Section C

- Biofertilizers, biopesticides, compost & vermicompost.
- Biofuels: Biogas, bioethanol, biodiesel, biohydrogen. Biodegradable plastics.
- Biodegradation of xenobiotic compounds: Simple aromatics, chlorinated polyaromatic petroleum products & pesticides; role of degradative plasmids.
- Solid waste management: types, treatment & disposal strategies.
- Bioleaching of metals, microbially enhanced oil recovery. Bioindicators.

Suggested Books

- Allen, K. (2016). *Environmental Biotechnology*. New Delhi, India: CBS Publishers.
- Miller, G.T. (2004). *Environmental Science: Working With The Earth* (10th ed.). Singapore: Thomson Asia.

- Milton, W. (Ed.). (1999). *An Introduction to Environmental Biotechnology*. USA: Springer.
- Modi, P. N. (2015). *Sewage treatment & disposal and waste water engineering*. New Delhi, India: Rajsons Publications Pvt. Ltd.
- Odum E. P. (2006). *Fundamentals of Ecology* (5thed.). Boston, US: Cengage.
- Sharma, P.D. (2008). *Environmental Biology and Toxicology*. Meerut, India: Rastogi Publications.
- Sodhi, G.S. (2002). *Fundamental Concepts of Environmental Chemistry*. New Delhi, India: Narosa Publishing House.
- Tripathi, B. N., Shekhawat, G. S., & Sharma, V. (Ed.). (2009). *Applications of Biotechnology*. Jaipur, India: Aavishkar Publishers.
- Vallero, D.A. (2016). *Environmental Biotechnology: Abiosystems approach*. US: Elsevier.
- Wright, R. T. (2015). *Environmental Science: Toward a Sustainable Future*. UK: Pearson Education.

Suggested e-resources

- **Ecosystem structure**
<http://www.biologydiscussion.com/ecosystem/ecosystem-its-structure-and-functions-with-diagram/6666>
- **Radioactive waste treatment**
<https://ehs.unc.edu › Manuals › Radiation Safety Manual>
- **Environmental Remediation**
https://www.iaea.org/sites/default/files/18/05/environmental_remediation.pdf
- **Biological treatment of wastewater**
<http://www.neoakruthi.com/blog/biological-treatment-of-wastewater.html>
- **Biogas**
<http://www.biologydiscussion.com/biomass/production-of-biogas-from-biomass/10436>
- **Biofuel**
<http://uru.ac.in/uruonlinelibrary/BioFuels/Biomass%20and%20biofuels.pdf>
- **Biological treatment of wastewater**
<http://www.neoakruthi.com/blog/biological-treatment-of-wastewater.html>
- **Xenobiotic compound biodegradation**
<http://www.biologydiscussion.com/microbiology-%202/bioremediation/xenobiotic-compounds-meaning-hazards-and-biodegradation/55625>

Environmental Challenges and Disaster Management

Max. Marks : 100
(ESA: 100)

L	T	P	C
0	0	0	2

Learning Outcomes:

After the completion of this course, students should be able to:

- Explain approaches to study environmental development and crisis.
- Describe world energy crisis with its causes and suggested measures for improvement.
- Describe several environmental problems their causes, consequences and mitigation.
- Depict the major disasters and their management with the help of case studies.

Course Content:

Environment:-Definition and types of Environment; Environmental Development Crisis:-Introduction and its causes; Energy Crisis:- Concept, Causes and Remedies; Environmental issues associated with Green Revolution; Impact of Urbanization on Environment.

Deforestation:- Concept, Causes, Effects and Conservation; Desertification:- Concept, Causes, Impacts and Preventions; Water Scarcity:- Causes ; Methods of Rain Water Harvesting (special reference to Traditional Methods); Acid Rain:- Causes, Consequences and Mitigation Measures; Solid Waste:- Introduction, Types and Management.

Disaster:- Definition and Classification; Natural Disaster:- Nature and Types; Flood:- Causes, Impacts and Methods of Management; Earthquake:- Introduction, Types, Causes, Effects and Mitigation; Case Studies:- Bhuj Earthquake-2001, Tsunami (Southern India)-2004 and Kedarnath Disaster-2013.

Stencils are to be permitted during the examination.

Recommended Books:

1. Gautam, A. (2010). *Environmental Geography*. Allahabad, India: Sharda Pustak Bhawan.
2. Ghosh, G. K. (2015). *Disaster Management*. New Delhi, India: A.P.H.
3. Singh, S. (2002). *Physical Geography*. Gorakhpur, India: Vasundhara.

Suggested e-learning materials:

1. Deforestation:- Concept, Causes, Effects
<https://www.livescience.com/27692-deforestation.html>
2. Acid Rain:- Causes, Consequences and mitigation measures <https://www.conserve-energy-future.com/causes-and-effects-of-acid-rain.php>
3. Solid Waste:- Introduction, Types and Management
<https://www.indiawaterportal.org/topics/solid-waste>

Environmental Chemistry

Max. Marks : 100

L T P C

(CA: 40 + ESA: 60)

4 0 0 4

Learning Outcomes:

After the completion of this course, students will be able to:

- Describe the various chemical processes occurring in the air, water and soil.
- Explain the effect of hydrocarbons and synthetic compounds on biological organisms.
- Explain the degradation of hydrocarbon and synthetic compounds.
- Illustrate the working principle, merits and demerits of analytical techniques.

Course Content:

Section A

Concept and Scope of Environmental Chemistry: Definition and explanation for various terms, segments of environment. Principles and cyclic pathways in the environment: Sulphur, Oxygen, Nitrogen, Phosphorous cycle.

Chemistry of Water: Unusual physical properties, unusual solvent properties, changes in water properties by addition of solute.

Soil Chemistry: Formation, constituents and properties of soils, adsorption of contaminants in soil, soil fertility, surface exchange reaction, soil redox potential and adsorption-desorption.

Section B

Chemistry of various organic, inorganic, carcinogenic compounds and their effects. Hydrocarbons: Chemistry of hydrocarbon decay, environmental effects, effects on macro and micro organisms. Surfactants: Cationic, anionic and nonionic detergents, modified detergents.

Pesticides: Classification, degradation, analysis, pollution due to pesticides and DDT problems.

Synthetic Polymers: Microbial decomposition, polymer decay, ecological and consideration, Photosensitize additives.

Aflatoxin occurrence, chemical composition and properties metabolism.

Section C

Physico-Chemical methods for analysis of environmental samples: Definition and determination of conductivity, pH, COD, BOD.

Principle, merits and demerits of Centrifuge, and Ultra centrifuge.

Principle, merits and demerits of the techniques: colorimetry, atomic absorption spectroscopy, Atomic emission Spectroscopy, gas chromatography, HPLC, ion exchange chromatography.

Recommended Books:

1. Bhatia, S. C. (2006). *Environmental Chemistry*. New Delhi, India: CBS.

2. De, A. K., & De, A. K. (2007). *Environmental Chemistry*. New Delhi, India:New Age International.
3. Gary, W.V., & Stephen, J. D. (2010). [*Environmental Chemistry*](#). *A global perspective*(3rded.). London, UK:Oxford University Press.
4. Rao, P. V. (2006). *Principles of Environmental Science and Engineering*. New Delhi, India:PHI.
5. Séamus, P. J. H. (2003). *Analytical Chemistry*. London, UK:Oxford University Press.
6. Manahan, S., &Manahan, S. E. (2009). *Environmental Chemistry (Ninth Edition)*. Florida, FL: CRC Press.
7. Wilson, K., &Walker, J. (2010). *Principals and Techiniques of Biochemistry and Molecular Biology*. New York, NY:Cambridge University Press.

Suggested e-learning materials:

1. Environmental Chemistry and Analysis [https://nptel.ac.in/courses/ 122106030/](https://nptel.ac.in/courses/122106030/)
2. Environmental Chemistry
<https://swayam.gov.in/course/251-environmental-chemistry>
Syllabus pertains to ENVS 405 of Department of Environment Science

Environmental Geology

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

After the completion of this course, students should be able to:

- Explain the application of geologic information to the entire spectrum of interactions between people and physical environment.
- Describe and mitigate the exposure of natural hazards on humans.
- Elucidate several types of pollutions and their sources.
- Explain the vulnerability of natural hazards.

Course Content:

Section A

Fundamental concepts of Environmental Geology. Introduction to Natural hazards: Causes and Impact. Types of Hazards. Earthquakes, Tsunami, volcanoes, Landslides and Floods.

Section B

Natural Resources. Environmental aspects of natural resource development and Management: Water resources, Mineral resources and Fossil fuels.

Section C

Pollution, their sources and types. Air Pollution, Pollution of rivers, lakes and groundwater.

Recommended Books:

1. Bryant, E. (1985). *Natural hazards*. London, UK: Cambridge University Press.
2. Keller, E.A. (1978). *Environmental Geology*. New Jersey, NJ: Bell and Howell.
3. Montgomery, C.W. (2011). *Environmental Geology*. New York, NY: McGrawHill.
4. Reichard, J. S. (2011). *Environmental Geology*. New York, NY: McGrawHill.
5. Smith, K. (1992). *Environmental hazards*. London, UK: Routledge.

Suggested e-learning materials:

1. Environment science
2. <https://epgp.inflibnet.ac.in/ahl.php?csrno=448>
<https://nptel.ac.in/courses/105105106/>

Environmental Geology and Hydrogeology

L T P C
5 0 0 5

Max. Marks : 100
(CA:40+ESA:60)

Section A

Fundamental concepts of environmental Geology. Natural hazards: landslides, floods, earthquakes, volcanoes and water logging. Environmental aspects of natural resource development: water resources, mineral resources and fossil fuels.

Section B

Pollution, their sources and types. Pollution of rivers, lakes and groundwater. Problem of Arsenic and fluoride and remedial measures for their treatment. Waste disposal practices and management. Waste water treatment. Watershed management. Artificial recharge of groundwater. Rain water harvesting.

Section C

Groundwater: origin and age of groundwater. Hydrological cycle, Precipitation, Evapotranspiration and Infiltration. Vertical distribution of groundwater. Aquifers: Geologic formation as aquifers and types of aquifers. Saline water intrusion: Occurrence, sea water intrusion in coastal areas and control of saline water intrusion. Groundwater regimes in India. Groundwater exploration. Well hydraulics.

Books Recommended:

1. Bryant, E. (1985) Natural hazards, Cambridge University Press, London
2. David K. Todd and Larry W. Mays (2004) Groundwater Hydrology, Wiley India (New Delhi)
3. H.M. Raghunath (2014) Groundwater, New Age International Publishers, New Delhi
4. H.S. Nagabhushaniah, (2001) Groundwater in Hydrosphere, CBS Publishers and Distributors, New Delhi
5. Karanth, KR (1989) Hydrogeology, Tata McGraw Hill Publications, New Delhi
6. Keller, E.A. (1978) Environmental Geology, Bell and Howell, USA
7. Smith, K., (1992) Environmental hazards, Routledge, London

Environmental History and Global Politics in Post-Cold War Era

Max. Marks : 100

L	T	P	C
0	0	0	2

Course Description:

Environmental History, which deals with the study of the relationship between human societies and natural world, has been relatively a new field of historical investigation. The study on the role of natural resources in global security and political economy began in the mid of nineteenth century. However, much of the literature prior to 1980s related specifically to resource extraction and developmental issues. In the late 1990s, global environmental politics began to establish itself as a distinct field within the broader frame of Environmental History. In this context, the focus of study expanded to include global environmental problems (climate change, ecological dislocation, ozone depletion, deforestation, and desertification) and policies such as- Earth Summits in Rio de Janeiro (1991) and Johannesburg (2001); Kyoto Protocol (1994); United Nations Climate Change Conference in Paris (2015) and others. Amidst these issues, the post-cold war era also saw the contradictions between the interests of developed and developing countries and the east and west on the issues of industrialization, carbon emission and sustainable development. In this light, the environmental history and Global politics in post-Cold war has emerged as a center of interdisciplinary and transnational work that integrates research from a range of fields including geography, economics, history, law, biology, etc. This course enables the students to understand the key debates, policy matters and issues in global environmental politics.

Learning Outcomes:

After completion of the course, the student will be able to:

- Comprehend the linkages between global politics and environmental issues.
- Understand the environmental policies discussed at various earth summits.
- Develop an insight to the interdisciplinary research from a range of fields including geography, economics, history, law and biology.

Recommended Books:

1. Fiege, Mark (2012), *The Republic of Nature: An Environmental History of the United States*. Seattle: University of Washington Press,
2. Immerman, Richard H. and Petra Goedde. *The International Environmental Movement and the Cold War*. Oxford University Press.
3. McNeill, J.R. and Corinna R. Unger. (eds.) (2010). *Environmental Histories of the Cold War*. New York: Cambridge University Press.
4. Oreskes, Naomi and Erik Conway (2014), *The Collapse of Western Civilization: A View from the Future*. Columbia University Press, 2014.
5. Tucker, Richard P. and Edmund Russell, eds., (2004), *Natural Enemy, Natural Ally: Toward an Environmental History of War*, Corvallis: Oregon State Press.

Suggested E-Resources:

- Cadiou, Jean-Marie . 'The Environmental Legacy of the Cold War', <https://www.nato.int/DOCU/review/1993/9305-7.htm>
- Laakkonen, Simo, Viktor Pál & Richard Tucker, 'The Cold War and environmental history: complementary fields', <https://www.tandfonline.com/doi/pdf/10.1080/14682745.2016.1248544?needAccess=true>
- Murkowski, Frank H. 'The Environmental Legacy of the Cold War', <http://arcticcircle.uconn.edu/VirtualClassroom/Chariot/murkowski1.html>

Environmental Law

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	1	0	5

Learning Outcomes:

- The students will be able to evaluate and formulate environmental law and policy.
- The students will be able to understand effectively the working of the Institutions relating to environment.
- The students will be able to develop ability to assess the social and ecological impacts of environmental law and policy.

Note: The paper will contain ten questions having at least two questions from each unit. Candidates are required to attempt five questions in all taking at least one question from each unit.

Unit I Introduction Environment – Meaning and Scope; environmental pollution: Definitions, Sources & Kinds, Need for Legal Control of Pollution, Indian Environmental Ethics, Constitutional Provisions, International Perspective: U.N. Conference on Human Environment, 1972 – Stockholm Principles, Establishment of Environmental Institutions like UNEP, World Charter for Nature, 1982, Ozone Protection – Montreal Protocol for the Protection of Ozone Layer, 1987 as amended, U.N. Conference on Environment and Development, 1992 - Rio Principles; U.N. Convention on Biological Diversity, 1992; Cartagena Protocol on Biosafety, 2000; U.N. Convention on Climate Change, 1992, Kyoto Protocol, 1997; Forest Principles; Agenda 21, Johannesburg Conference, 2002, Delhi Summit, 2002. Fundamental Principles of Environmental Protection: Sustainable Development, Inter-generational and Intra-generational Equity; Precautionary Principle; Polluter Pays Principle; Public Trust Doctrine.

Unit II The Environment Protection Act, 1986, with Rules: Aims and Objects; Meaning of “Environment” and “Environmental Pollutant”; Powers and Functions of the Central Government; Environment Authority - Constitution; Delegation Powers; Offences/Penalties; Effectiveness of the Act; The Hazardous Wastes (Management and Handling) Rules, 1989 as amended in 2000 and 2003; Noise Pollution – Definition, Causes, Effects, Legal Remedies, Noise Pollution (Regulation and Control) Rules, 2000, Environment Impact Assessment Rules 2006, Coastal Zone Management Regulation, 2010.

Unit III The water (Prevention and Control of Pollution) Act, 1974- Definitions, constitution of the Boards, Powers of the Boards. The Central Government: Prosecution Procedure and Punishment.

The Air (Prevention and Control of Pollution) Act, 1981- Definitions, Constitution, Power & Functions of Boards, Powers of the Central Government, Prosecution procedure and punishment.

Unit IV The Indian Forest Act, 1927: Kinds of Forest Land - Private, Reserved, Village, Protected; The Forest (Conservation) Act, 1980, De-reservation of Forests - Non-Forest Use of Forest Land; Rights of Tribals, Forest Dwellers; Use of Forest Land - Mining, Eco-Tourism, Mega Projects.

Unit V The Wildlife Act, 1972 – Definition, wildlife sanctuaries, wildlife / parks, offences under the Act, kinds of forest offences and punishments under the Act. The Prevention of Cruelty to Animals Act, 1960, Greenhouse Effect – Causes, Effects, Remedies, International declaration regarding it.

Leading Cases:

1. Indian Council for Enviro-Legal Action v/s Union of India, AIR 1996 SC 1446 (Bichhri Village Case)
2. Narmada Bachao Andolan v/s Union of India, AIR 2000 SC 3751

3. M.C. Mehta v/s Union of India, AIR 2002 SC 1696 (CNG Vehicles case)
4. Rural Litigation and Entitlement Kendra v/s State of U.P, AIR 1983 SC 652 (Dehradun Mussorie Hills Quarrying case), (1985) 2 SCC 431
5. M.C. Mehta v/s Union of India, AIR 1997 SC 734 (Taj Trapezium case)
6. M.C. Mehta v/s Union of India, (2006) 3 SCC 399 (Closure of Industries in Delhi)
7. M.C. Mehta v/s Union of India, AIR 1988 SC 1037 (Kanpur Tanneries case)
8. M.C. Mehta v/s Union of India, AIR 1988 SC 1115 (Municipalities case)
9. M.C. Mehta v/s Union of India, (Oleum Gas Leakage) & AIR 1987 SC 1086
10. U.P. Pollution Control Board v/s Dr. Bhupendra Kumar Modi, (2009) 2 SCC 147
11. T.N. Godavarman Thirumanipad v/s Union of India, (1997) 2 SCC 267
12. Vellore Citizen welfare forum v/s Union of India, (1966) 5 SCC 647
13. In re Noise Pollution, (2005) 5 SCC 733
14. M.C. Mehta v/s Kamal Nath, (1997) 1 SCC 388
15. U.P. Pollution Control Board v/s Mohan Meakins Ltd., (2000) 3 SCC 745

Suggested Readings:

1. Diwan, S. and Rosencranz, Armin.(2002). *Environmental Law and Policy in India*. New Delhi.: Oxford University Press,
2. Sahasranaman,P.B.(2009). *Handbook of Environmental Law* New Delhi.: Oxford University Press,
3. Doabia,T.S.(2010). *Environmental and Pollution Laws in India*.Lexis Nexis, Butterworths Wadhwa.

Suggested E- Learning Material:

1. Lecture _39 environmental laws, by IIT Kanpur, National Program on Technology Enhanced Learning(NPTEL),an MHRD initiative Retrieved from <https://www.youtube.com/watch?v=CTUOchYZG2k>
2. Environmental laws video Lectures, by Prof. Mukesh Sharma, free video lectures. Retrieved from <http://free video lectures.com>

Environmental Legislation

Max. Marks : 100

(CA: 40 + ESA: 60)

Learning Outcomes:

L	T	P	C
4	0	0	4

After the completion of this course, students will be able to:

- Explain fundamental concepts in environmental law and policy.
- Describe the main Environmental Law and Policy regime of the country.
- Outline various international environmental laws incorporated into environmental policies of national and state governments.
- Examine and analyse legal approaches to pollution control, environmental planning and natural resource management.
- Examine implementation issues associated with environmental regulation and environmental regimes

Course Content:

Section A

Fundamental Principles of Domestic and International Environmental Law

State sovereignty, co-operation, Indian Constitutional provision (Fundamental rights, Directive principal of State Policy and Fundamental duties) role of courts

Key elements of some International Declarations (Stockholm, Rio declaration, Agenda 21, Kyoto protocol on Climate Change)

Sustainable development: Polluter Pay Principle, Precautionary Principle, Preventive Principle, Intergenerational Equity

Section B

Domestic Laws on Environment

The Environmental Protection Act 1986, Definition of pollution and pollutant

Power of Central government, The water (Prevention and Control of Pollution) Act 1974 – Definitions, Construction Power and functions of Boards

The Air (Prevention and control of Pollution) Act, 1981 – Definitions, Constitution Power and functions of Boards.

National Green Tribunal Act 2010

Section C

Environment Related Other Laws and Policies

The Forest conservation Act 1980, The Wildlife Act 1972, Prevention of Cruelty to Animals Act, 1960. Environmental Impact Assessment Rules 2006, Bio-Medical waste (management & handling) rules 1998, Hazardous waste (Management and Handling) Rules 1989 and 2000)

Recommended Books:

1. Bhatt, S. (2004). *Environment Protection and Sustainable Development*. New Delhi, India: APH.
2. Diwan, S. & Rosencranz, A. (2002). *Environmental Law and Policy in India* (2nded.). New Delhi, India: Oxford University Press.
3. Leelakrishnan, P. (2010). *Environmental Law in India* (3rded.). New York, NY: Lexis Nexis.
4. Naseem, M., & Naseem, S. (2018). *Interational Environmental Law*. Netherlands: Wolters Kluwer.
5. Sahasranaman, P.B. (2012). *Handbook of Environmental Law* (2nded.). New Delhi, India: Oxford University Press.
6. Shantha, K. S. (2008). *Introduction to Environmental Law* (2nded.). New York, NY: LexisNexis.

Suggested e-learning materials:

1. Environmental Legislation in India, <https://nptel.ac.in/courses/105104099/39>
2. Environmental Law
<https://swayam.gov.in/courses/5163-environmental-law>

Environmental Remote Sensing and Modeling

Max. Marks : 100

L	T	P	C
0	0	0	2

Learning Outcomes:

After the completion of this course, students should be able to:

- Describe principles of environmental modeling and taxonomy of environmental models in the spatial sciences.
- Explain Remote Sensing applications to monitoring wetland dynamics and management of Ramsar sites.
- Apply concepts of remote sensing in urban biophysical environmental modeling and management.
- Explain methods and benefits of Environmental Impact Assessment (EIA).

Course Content:

Principles of environmental modeling. Taxonomy of environmental models in the spatial sciences. Basic concept, Environmental Impact Assessment (EIA): Basic concepts, method, and Benefit. Integrated Environmental Modeling (IEM): A vision and roadmap for the future. Sensitivity Analysis: Importance in environmental modeling. Spatial multi-criteria evaluation and environmental modeling. Application of remote sensing in solid waste management, water pollution monitoring and air pollution monitoring. Remote Sensing of urban biophysical environment: components and “urban heat islands” monitoring. Remote Sensing applications to monitoring wetland dynamics: Functions and values of Ramsar Sites (India). Aboveground terrestrial biomass and carbon stock estimations from Multi-sensor remote sensing: Global carbon budgets and remote sensing. Ecological characterization of vegetation using multi-sensor remote sensing in the solar reflective spectrum. Principles and Practices of data fusion in multi-sensor remote sensing for environmental monitoring.

Recommended Books:

1. Brimicombe, A. (2009). *GIS, Environmental Modeling and Engineering* (2nded.). Boca Raton, FL: CRC Press.
2. Chang, N. B., & Bai, K. (2018). *Multisensor Data Fusion and Machine Learning for Environmental Remote Sensing*. Boca Raton, FL: CRC Press.
3. Joshi, P. K., & Singh, T. P. (2011). *Geoinformatics for Climate Change Studies*. New Delhi, India: TERI Press.
4. Joshi, P. K., Pani, P., Mohapatra, S. N., & Singh, T. P. (Eds.). (2010). *Geoinformatics for Natural Resource Management*. Punjab, India: Nova.
5. Reddy, G. P. O., & Singh, S. K. (Eds.). (2018). *Geospatial Technologies in land resource mapping, monitoring and management*. New York, NY: Springer-nature.
6. Skidmore, A. (2002). *Environmental Modelling with GIS and Remote Sensing*. London, United Kingdom: CRC Press.
7. Thenkabail, P. S. (2015). *Land Resources Monitoring, Modeling, and Mapping with Remote Sensing*. Boca Raton, FL: CRC Press.
8. Weng, Q. (2011). *Advances in Environmental Remote Sensing: Sensors, Algorithms, and Applications*. Boca Raton, FL: CRC Press.

Suggested e-learning materials:

1. Taxonomy of environmental models in the spatial sciences
<https://research.utwente.nl/en/publications/taxonomy-of-environmental-models-in-the-spatial-sciences>
2. Ramsar Convention
<https://www.ramsar.org/about-the-ramsar-convention>

Environmental Statistics and Research Methodology

Max. Marks : 100

L T P C

(CA: 40 + ESA: 60)

4 0 0 4

Learning Outcomes:

After the completion of this course, students will be able to:

- Apply statistical tools to perform data analysis and data interpretation.
- Develop problem formulation using multiple statistical relationships and solve them using standard techniques.
- Draw conclusions from the use of tables, graphs, and charts.
- Have the versatility to work effectively in a broad range of analytic and scientific positions.

Course Content:

Section A

Basic idea of Environmental Statistics and its applications in Environmental research. Collection, classification, tabulation of data. Frequency distribution Diagrammatic and graphical presentation of statistical data, sampling techniques. Central tendency – concept; arithmetic mean, median, mode for ungrouped and grouped data. Measures of dispersion: range, mean deviation, standard deviation and variance.

Section B

Probability, Binomial, Poisson and Normal Distribution, simple measure of Skewness and Kurtosis. Correlation and Regression: Karl Pearson correlation coefficient and Spearman rank correlation coefficient, Regression. Basic idea of significance testing, level of significance, Student's t-test, χ^2 (chi-square) test and F-test and analysis of variance (ANOVA).

Section C

Introduction of Research Methodology: Formulation of a research problem (Hypothesis). Simple experimental designs, Writing of Research Report/Research Paper: Review of literature, The IMRaD format, Citation and Impact factor, Science citation index (SCI)/ Science citation index Expanded (SCI-E), H-index, Citation style (APA, MLA) Academic Ethics and Plagiarism, Intellectual Property Rights and Patent law.

Recommended Books:

1. Basotia, G.R. & Sharma, K.K. (1999). *Research Methodology*. Jaipur, India: Mangal Deep.
2. Chaudhary, C.H. (2009). *Research Methodology*. Rajasthan, India: RBSA.
3. Daniel, W. (1987). *Biostatistics: A Foundation for Analysis in the Health Sciences* (4th ed.). New York, NY: John Wiley & Sons Inc.
4. Elhance, D.N., Elhance, V., & Aggarwal, B.M. (2014). *Fundamentals of Statistics*. New Delhi, India: KitabMahal.
5. Gupta, S.P. (2014). *Statistical Methods* (43rd ed.). New Delhi, India: S. Chand.
6. Khan, I.A., & Khanum, A. (2009). *Fundamentals of Biostatistics*. Hyderabad, India: Ukaaz.
7. Zerold, J. (2008). *Biostatistical Analysis* (3rd ed.). Noida, India: Dorling Kindersley.

Suggested e-learning materials:

1. Descriptive Statistics- Measures of Central Tendency and Dispersion, <https://nptel.ac.in/courses/110106064/4>
2. Guidelines for Thesis Preparation
<http://www.iitk.ac.in/doaaold/thesisguide.pdf>
3. How to Write a Paper, Mike Ashby, Engineering Department
www-mech.eng.cam.ac.uk/mmd/ashby-paper-V6.pdf
4. Introduction to research
<https://nptel.ac.in/courses/121106007>
5. Methodology for Design Research
<https://nptel.ac.in/courses/107108011>
6. Research Writing
https://onlinecourses.nptel.ac.in/noc18_mg13/preview

संस्कृत साहित्य एवं पर्यावरण विज्ञान

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
5	0	0	5

निर्गम-

पाठ्यक्रम के सफलतापूर्वक अध्ययन के पश्चात् विद्यार्थी निम्नलिखित में समर्थ होंगे-

- वैदिक एवं लौकिक साहित्य सम्बन्धी ज्ञानावबोध में वृद्धि।
- पर्यावरण चेतन का विकास।
- शोध प्रवृत्ति का रुचिपूर्वक विकास।
- संस्कृत साहित्य को अन्तर्वैषयिक सम्बन्धों को समझने की क्षमता का विकास।

निर्देश :

- यह प्रश्न-पत्र तीन खण्डों में विभक्त है। प्रत्येक खण्ड से तीन-तीन प्रश्न पूछे जायेंगे।
- परीक्षार्थी को कुल पाँच प्रश्नों के उत्तर देने हैं। प्रत्येक प्रश्न के अंक समान हैं। प्रत्येक खण्ड में से अधिकतम दो व कम से कम एक प्रश्न का उत्तर देना अनिवार्य है।
- किसी भी एक प्रश्न का उत्तर संस्कृत भाषा के माध्यम से देना होगा।

प्रथम खण्ड- पर्यावरण का स्वरूप

पर्यावरण-परिचय और परिभाषा, पारिस्थितिकी तंत्र, पर्यावरण के कारक - भूतलीय कारक- पर्वत, वनस्पति, जलीय कारक-ताप, नदियाँ, मानसून, वर्षा, पवन, ऋतुएँ, जलवायु जैविक कारक- जीव-जन्तु, मानव-पर्यावरण सम्बन्ध, पर्यावरण समस्या: समाधान, पर्यावरण संरक्षण, महत्त्व एवं दायित्व

प्रतिपाद्य से सम्बद्ध समीक्षात्मक प्रश्न-

द्वितीय खण्ड- वैदिक साहित्य में पर्यावरण विज्ञान

प्रतिपाद्य से सम्बद्ध समीक्षात्मक प्रश्न

तृतीय खण्ड- कालिदास के साहित्य में पर्यावरण विज्ञान

प्रतिपाद्य से सम्बद्ध समीक्षात्मक प्रश्न

संस्तुत पुस्तकें

- ऋग्वेद संहिता, (1977), नई दिल्ली, वेद प्रतिष्ठान।
- अथर्ववेद, (1961), होशियारपुर, विश्वेश्वरानन्द वैदिक शोध संस्थान।
- कालिदास, रघुवंशम्, व्या. हरगोविन्द शास्त्री, (1953), वाराणसी, चौखम्बा संस्कृत सीरीज।
- कालिदास, कुमारसंभवम्, सं. सूर्यकान्त, (1966), दिल्ली, साहित्य अकादमी।
- कालिदास, ऋतुसंहारम्, (1962), वाराणसी, चौखम्बा संस्कृत सीरीज।
- कालिदास, अभिज्ञानशाकुन्तलम्, सं. कपिलदेव द्विवेदी, (1968), इलाहाबाद, रामनारायणलाल बेनीमाधव।
- मालविकाग्निमित्रम्, सं. माहनदेव पन्त, संसारचन्द्र, (1968), दिल्ली, मोतीलाल बनारसीदास।
- मेघदूतम्, व्या. शेषराजरेग्मी, (1987), वाराणसी, चौखम्बा विश्वभवन।
- चतुर्वेदी, सीताराम, (2014), कालिदास ग्रन्थावली, लखनऊ, उत्तरप्रदेश, संस्कृत संस्थान।
- रस्तोगी, वन्दना, (2000), प्राचीन भारत में पर्यावरण चिन्तन, जयपुर, पब्लिकेशन स्कीम।
- कुलश्रेष्ठ, सुषमा, शुक्ल, लक्ष्मी, कुलश्रेष्ठ, आभा, (2011), संस्कृत साहित्य एवं पर्यावरण, दिल्ली, ईस्टर्न बुक लिंकर्स।

- द्विवेदी, कैलाशनाथ, (2015), *कालिदास भूगोल*, जयपुर, रचना प्रकाशन ।

E- Resources

- Sanskrit Sahitya ka Itihaas
<https://archive.org/details/in.ernet.dli.2015.327677>
- Environmental Studiess
<https://books.google.co.in/books?id=FhI-JMGLfcC&printsec=frontcover#v=onepage&q&f=false>

आयुर्वेद एवं वनस्पति विज्ञान

Max. Marks : 100
(CA: 40 + ESA: 60)

L T P C
4 0 0 4

निर्गमः— पाठ्यक्रम के सफलतापूर्वक अध्ययन के पश्चात् विद्यार्थी निम्नलिखित में समर्थ होंगे।

- आयुर्वेद में निहित औषधीय ज्ञान से परिचय।
- स्वास्थ्य के प्रति चेतना में वृद्धि।
- वृक्षचिकित्सा की विविध प्रविधियों का ज्ञान।

निर्देशः— यह प्रश्नपत्र पाँच अन्वितियों में विभक्त है। प्रत्येक अन्विति के लिए 12 अंक निर्धारित हैं।

अन्विति प्रथम — आयुर्वेद का संक्षिप्त इतिहास आयुर्वेद परिच्छेदः आचार्य परिच्छेदः

द्वितीय अन्विति — काश्यप संहिता— सूत्र स्थानम् लेहाध्यायः

तृतीय अन्विति — वृक्षायुर्वेद का संक्षिप्त इतिहास

चतुर्थ अन्विति — वृक्षायुर्वेद—सुरपाल पद्य 35 से 292 तक वृक्षारोपण हेतु भूमि चयन, वृक्षारोपण विधि, सिंचन विधि, रोग, एवं उपचार।

पंचम अन्विति — काश्यप संहिता एवं वृक्षायुर्वेद के प्रतिपाद्य से सम्बद्ध दो प्रश्न।

परीक्षा योजना

समय— तीन घण्टे

पूर्णांक 60 अंक

नोट : यह प्रश्नपत्र पाँच अन्वितियों में विभक्त है। प्रत्येक अन्विति अथवा उसके विभागों के साथ लिखे गये संकेत के अनुसार प्रश्न पूछे जाएंगे।

अन्विति 1 निर्धारित अंश से सम्बद्ध एक निबंधात्मक प्रश्न = 12 अंक

अन्विति 2 निर्धारित अंश से सम्बन्धित एक प्रश्न अथवा दो टिप्पणी 6+6 = 12 अंक

अन्विति 3 निर्धारित अंश से सम्बन्धित एक प्रश्न अथवा दो टिप्पणी
6+6 = 12 अंक

अन्विति 4 निर्धारित अंश से सम्बन्धित एक प्रश्न अथवा दो टिप्पणी
6+6 = 12 अंक

अन्विति 5 निर्धारित अंश से सम्बन्धित दो प्रश्न 6+6 = 12 अंक

कुल योग = 60 अंक

संस्तुत पुस्तकें—

- आयुर्वेद महाकोशः अर्थात् आयुर्वेदीय शब्दकोशः संस्कृत — संस्कृत द्वितीयः खण्डः जय कृष्णदास आयुर्वेद ग्रन्थमाला (संख्या-1)
- आचार्य, प्रियव्रत शर्मा, (1975), वाराणसी, चौखम्भा ओरियन्टलिया।
- आयुर्वेद का बृहत् इतिहास, उत्तरप्रदेश, (हिन्दी समिति ग्रन्थमाला -33) अत्रिदेव विद्यालंकार प्रकाशन।
- संस्कृत साहित्य में आयुर्वेद — सम्पादक— डॉ. मोनिका एवं डॉ. दीपमाला गहलोट (2018), जोधपुर।
- शर्मा, हेमराज, (काश्यप संहिता वृद्धाजीवकीयं तन्त्रं वा) (काशी संस्कृत ग्रन्थमाला) 154 विद्योतिनि हिन्दी व्याख्या) राजस्थानी ग्रंथागार।
- गर्ग, गोपाल शरण, वनौषधि रत्नाकर, (चतुर्थ भाग) काश्यप संहिता (वृद्धजीवकीयं तन्त्रम वा)

- मिश्र योगेश चन्द्र काश्यप *संहिता का सांस्कृतिक मूल्यांकन (कृष्णदास आयुर्वेद सीरीज)* (2001) ,वाराणसी, चौखम्भा कृष्णदास अकादमी।
- जुगनू डॉ. श्रीकृष्ण, (2010), *वृक्षायुर्वेद: सुरपालमुखी*, वाराणसी, चौखम्भा संस्कृत सीरीज।

E-Resources-

- Aayurveda
<https://archive.org/details/in.ernet.dli.2015.170332/page/n5>
- Aayurveda Siksha
<https://archive.org/details/in.ernet.dli.2015.64073/page/n19>

Advanced Food Science

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

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

- Apply and incorporate the principles of Food Science in practical, real-world situations and problems
- Explain the basic principles of sensory analysis and other analytical techniques associated with food
- impart awareness on the concept of ‘new food product development’ and current topics of importance to the Food industry
- Apply the various techniques in the quality evaluation of foods and demonstrate practical proficiency in a food analysis laboratory

Syllabus :

Section A

1. Colloidal chemistry as related to foods. Food emulsions and foams
2. Carbohydrates in food
 - a) Sugar: Manufacturing process of sugar, stages of sugar cookery, sugar products
 - b) Polysaccharides
 - i. Starch : Structure, gelatinization, retrogradation, syneresis, gelation, modified food starches, dextrinization
 - ii. Non Starch Polysaccharides: Cellulose, hemicellulose and pectins – sources, characteristics in foods
 - c) Cereals – Structure and composition of wheat and rice
 - i. Flours and flour quality
 - ii. Breakfast cereals

Section B

1. Protein in Foods:
 - a) Plant foods – pulses, nuts and oilseeds; composition. Antinutritional factors. Fermentation and germination in legumes. Cooking quality
 - b) Animal foods –
 - i. Milk – Composition, spoilage and care. Physical and chemical properties
 - ii. Meat, fish and poultry – Structure and composition, Evaluation of egg quality and grading. Use of egg in cookery Postmortem changes in meat
2. Fats and Oils:
 - a) Physical and chemical properties
 - b) Rancidity changes
 - c) Antioxidants and synergists
 - d) Changes during frying and storage

Section C

1. Fruits and Vegetables – Classification and composition.
 - Effect of heat on vegetables.
 - Preservation of vegetables and fruits.
 - Food Pigments.
 - Browning Reactions.
2. Food Additives: Definition, importance, classification and uses.
3. Leavening Agents : Importance, classification, nature and use.
4. New Food Product Development: Definition, factors shaping new product development – Social concerns, health concerns, impact of technology and market place influence

5. Sensory Evaluation
 - a) (i) Selection of panel of judges
 - (ii) Types of tests (an overview)
 - (iii) Judging
 - b) Objective methods for measurement of:
 - (i) Colour
 - (ii) Texture

References :

1. Belitz, H.D. & Grosch, W. (1999). *Food Chemistry*. (2nd ed.) New York: Springer.
2. Charley, H. (1982). *Food Science* (2nd ed.) New York: John Wiley and Sons.
3. Manay, N.S. & Shadarsharaswamy, M. (1987). *Foods, Facts and Principles*. New Delhi: Wiley Eastern Ltd.
4. Meyer, L.H. (1978). *Food Chemistry*. New York: Reinhold Book Corporation.
5. Potter, N. & Hotchkins, J.H. (1996). *Food Science* (5th ed.). New Delhi: CBS Publishers and distributors.
6. Srilakshmi, B. (2001). *Food Science* (2nd ed). New Delhi : New Age International Pvt. Ltd.

E –Resources:

- <https://opened.uoguelph.ca/student-resources/food-science-certificate-> Food Science Certificate
- [https://www.academiccourses.com/Courses/Food-Sciences/Distance-learning/-](https://www.academiccourses.com/Courses/Food-Sciences/Distance-learning/)

Advanced Nutrition Max. Marks : 100

(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

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

- Apply various methods of estimation of body composition
- estimate protein quality of food stuffs
- estimate nutritional requirements of different groups and make recommendations through life cycle
- conduct laboratory and anthropometric methods of assessment of nutritional status

Section A

1. Development of Nutrition as a science, metamorphosis of the science of nutrition in historical perspective
2. Body Composition: Concept of body composition biochemical composition, Nutritional anthropometry, Skin fold thickness, measurement and calculation of body density using Archimedes' principle and hydrometry. Calculation of percent body water and body fat from body density. Dilution techniques and calculation of indices of body composition. Lean body weight and fat free body weight. Concept of body cell mass and its determination by isotopic measurement. Application of body composition data
3. Evaluation of protein quality :In vitro evaluation- Chemical score, Protein digestibility coefficient, PDCAAS
In vivo evaluation- Biological value (BV), Net protein utilization (NPU), Protein efficiency ratio (PER), NDP caloric percent.

Section B

1. Concepts of energy expenditures and their application. Units of energy, measurement of energy expenditure by direct and indirect calorimetry. Calculation of non protein respiratory quotient and its conversion to quantity of carbohydrate and fat (in grams) metabolized. Determination of amount of protein metabolized and calculation of total heat production of the diet, basal metabolism, BMR and its measurement. Calculation of surface area from equations and monograms, SDA of food and its interpretation, calculation of energy expenditure of an average reference man and woman, regulation of energy balance
2. Perspectives in human nutritional requirements. Different methods of estimating nutritional requirements and their critical evaluation. Estimation of Energy, Protein, Fat, Iron, Calcium, vitamin A and vitamin C requirements
3. Regulation of food intake: Hunger and appetite, gastrointestinal factors in the regulation. Role of hypothalamus, glucose utilization in the body and fat stored in the body as regulators of food intake, regulation of body weight

Section C

1. Nutrition, immunity and infection. Innate and adaptive immunity. Primary and secondary lymphoid organs. Cell mediated and humoral immunity. T and B lymphocytes, antibody response, primary and secondary infection . Role of nutrition in immune functions, Immune aberrations – AIDS
2. Nutrition and stress - Stress types, Body's response (endocrine and metabolic) to short term and long term stress. Role of nutrition in stress coping
3. Non nutritive food components with potential health effects- polyphenols, tannins, phytates, phytoestrogens

References :

1. *Annual Reviews of Nutrition*(1981). California USA : Annual review INC
2. Bamji M.S., Krishnaswamy, K., Brahmam G. N. V. (2017). *Text Book of Human Nutrition*4th Ed.. New Delhi : Oxford and IBH publishing Co Pvt. Ltd..
3. Davidson, S. S., Passmore, L., Eastwood, M. A. (1986).Davidson and Passmore *Human Nutrition and Dietetics*. Churchill Livingstone

4. Pike, R. L., Brown, M. L. (1984) *Nutrition – An integrated approach*. Canada : John Wiley and Sons.
5. Sharma S., (2000). *Human Nutrition and Meal Planning*, Delhi : Jnanda prakashan.

E-reference :

1. Nutrient Requirements and Recommended Dietary Allowances for Indian
A Report of expert group of ICMR 2009
<http://www.scribd.com/document>

BOTANY

Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
6	0	0	6

Learning Outcomes::

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

- Acquaint with the general characters and classification of cryptogams and phanerogames.
- Understand the evolutionary relationship among lower to higher plant species with differentiating characteristics.
- Appreciate and understand economic importance and application of every group of plants.

Unit 1

- Algae: Classification, general account with special reference to *Anabaena*, *Oscillatoria*, *Volvox*, *Chara*, *Oedogonium*, *Ectocarpus*, *Polysiphonia*. Economic importance of algae.

Unit 2

- Fungi: Classification, general account with special reference to *Albugo*, *Aspergillus*, *Puccinia*, *Ustilago* and *Alternaria*. Economic importance of fungi.

Unit 3

- Bryophytes: Classification, general account with special reference to important features in the life cycles of *Riccia*, *Marchantia*, *Anthoceros* and Mosses: *Funaria*, *Sphagnum*.

Unit 4

- Pteridophytes: Classification, general account, evolution of stelar systems, apospory, apogamy and seed habit. Outline of life cycle of *Selaginella*, *Equisetum* and *Marsilea*.

Unit 5

- Gymnosperms: Classification and evolution, distribution with special reference to Indian gymnosperms. Special features in life cycle of *Cycas*, *Pinus* and *Ephedra*. Economic importance.

Suggested Books:

- Alam, A. (2015). *Text book of Bryophyta*. New Delhi: I K International Publishers.
- Alexopoulos, C. (1979). *Introductory Mycology*. New York: John Wiley & Sons.
- Bhatia, K. (1975). *A Treatise on Algae*. New Delhi: S. Chand & Company.
- Biswas, C., & Johri, B.M. (2010). *Gymnosperm*. Springer-Verlag Berlin and Heidelberg GmbH & Co. KG
- Chamberlain, C.J. (1919). *Morphology of Gymnosperms*. Allahabad: Central Book Depot.
- Chapman, V.J. (2013). *An Introduction to the Study of Algae*. UK: Cambridge University Press.
- Dubey, H.C. (2011). *Introduction to Fungi*. India: Vikas Publishing House.
- Dutta, S.C. (1967). *Introduction to Gymnosperms*. Asia Publishing House.
- Ganguli, H.C., Das, K.S., & Dutta C. (2011). *College Botany* Vol. I. India: New Central Book Agency.
- Kumar, H.D. (1999). *Introductory Phycology*. New Delhi: Affiliated East-West.

- Parihar, N.S. (1956). *Bryophyta Pteridophyta*. Allahabad: Central Book Depot.
- Rashid, A. (1999). *An Introduction to Pteridophyta*. New Delhi: Vikas publications.
- Saxena, S. (2000). *A text book of Botany* (Vol. I & II). Agra: Ratan Prakash Mandir.
- Sharma, O.P., & Gupta, R.C. (2010). *Text Book of Fungi*. IBH. New Delhi, India: Vedams eBooks (P) Ltd.
- Sporne, K.R. (1966). *Morphology of Pteridophytes*. London: Hutchinson University Library.
- Vashistha, B.R., & Sinha, A.K. (2010). *Botany for Degree Students-Algae*. New Delhi: S. Chand Publication.
- Vashistha, B.R., & Sinha, A.K. (2016). *Botany for Degree Students-Fungi*. New Delhi: S. Chand Publication.
- Vashistha, B.R., Sinha, A.K., & Kumar, A. (1987). *Botany for Degree classes- Gymnosperms*. New Delhi: S. Chand Publication.
- Vashistha, B.R., Sinha, A.K., & Kumar, A. (2010). *Botany for Degree Students-Bryophyta*. New Delhi: S. Chand Publication.
- Vashisthai, B.R., & Vashistha, P.C. (1987). *Botany for Degree Students Pteridophyta*. New Delhi: S. Chand Publication.
- Webster, J., & Weber, R. (2007) *Introduction to Fungi*. New York: Cambridge University Press.

Suggested e-Resources:

- **Bryophytes: General account, classification and structure**

<http://nsdl.niscair.res.in/jspui/bitstream/123456789/150/1/BRYOPHYTES%20.pdf>

- **Gymnosperms**

<http://www-plb.ucdavis.edu/courses/bis/1c/text/Chapter24nf.pdf>

Pteridophytes

<http://nsdl.niscair.res.in/jspui/bitstream/123456789/556/1/PTERIDOPHYTES%20april609%20-%20formatted.pdf>

Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms Lab

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
0	0	4	2

Learning Outcomes::

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

- Identify bryophyte and pteridophyte material for specimens of lower group of plants.
 - Interpret the characteristics & life cycles of various lower plants.
 - Learn about practical techniques in lab for detail study of plant structure and anatomy, reproduction.
1. Study of algae and fungi as mentioned in the syllabus (museum specimen of the affected plants and permanent prepared slides).
 2. Study of vegetative and reproductive parts in *Selaginella*, *Equisetum* and *Marsilea*.
 3. Study of vegetative and reproductive parts in *Riccia*, *Marchantia*, *Anthoceros* and *Funaria* by the preparation of temporary slides.
 4. Gymnosperms: Study of *Cycas* (coralloid root, rachis, leaflet, male cone, megasporophyll), *Pinus* (needle, dwarf shoot, long shoot, male cone, female cone) *Ephedra* (morphology, stem, male cone, female cone) by the preparation of temporary slides.

Suggested Books:

- Bendre, A., & Kumar, A. (2009). *A Textbook of Practical Botany- I*. Meerut: Rastogi Publications.

Angiosperms Taxonomy and Economic Botany

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
6	0	0	6

Learning Outcomes:

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

- Identify characteristic features of angiosperm families and their interdisciplinary approaches.
- Understand plant morphology terminologies and distinguishing features with morphological peculiarities.
- Know the economic importance of angiosperms and its use in various industries.

Unit-I

- International code of nomenclature for algae, fungi and plants- history, rules, principles. Concept of family, genus and species, citation of author's name.
- Numerical taxonomy and chemical taxonomy (brief ideas only).
- A brief account of national herbaria and botanical gardens of India.

Unit 2

- Classification: System of Bentham and Hooker, a brief account of classification by Engler and Prantl, Hutchinson and Takhtajan, merits and demerits.
- Study of following families with emphasis on their diagnostic features:
 - Ranunculaceae
 - Papaveraceae
 - Capparidaceae
 - Caryophyllaceae
 - Rutaceae
 - Myrtaceae
 - Malvaceae

Unit 3

- Study of following families with emphasis on their diagnostic features:
 - Cucurbitaceae
 - Rubiaceae
 - Asclepiadaceae
 - Apocynaceae
 - Asteraceae
 - Amaranthaceae
 - Acanthaceae

- Solanaceae
- Apiaceae
- Lamiaceae
- Euphorbiaceae
- Brassicaceae
- Fabaceae
- Caesalpinaceae
- Mimosaceae
- Poaceae
- Arecaceae
- Liliaceae

Unit 4

- Food plants: Maize, bajra, wheat, legumes, potato, sugarcane.
- Spices: General account (coriander, turmeric, chillies, *Cumin*, fennel, *Asafoetida*).
- Beverages: Tea and coffee.
- Fatty oils: Mustard, groundnut, sesame, coconut.

Unit 5

- Fibre plants: *Gossypium*, *Corchorus*, *Saccharaum munja*.
- Drug plants: *Cinchona*, *Rauwolfia*, *Papaver*, *Digitalis*.
- Timber plants: *Tectona*, *Dalbergia*, *Pinus*. Rubber: *Hevea brasiliensis*.

Suggested Books:

- Alam, A., & Sharma, V. (2012). *Economic Botany*. Jaipur: Pointer Publishers.
- Dutta, S. (2009). *A Hand Book of Systematic Botany*. New Delhi: New Age International (P) Limited.
- Khetrpal, Y.T. *An Introduction to the Taxonomy of Angiosperms*. Jaipur: Ramesh Book Depot.
- Kochhar, S.L. (2016). *Economic Botany of the Tropics*. London: Macmillan India Limited
- Kumar, A., & Bendra, A. (1983). *Economic Botany: for university students*. Meerut: Rastogi Publications.
- Lawrence, G.H.M. (2017). *Taxonomy of vascular plants*. Jodhpur: Scientific publisher
- Radford, A.R., & Caddell, G.M. (1986). *Fundamentals of Plant systematics*. USA: Harper & Row Publishers.
- Sharma, O.P. (2011). *Taxonomy of Angiosperm*. New Delhi: TATA McGraw-Hill.
- Singh, V., & Jain, D.K. (2010). *Taxonomy of Angiosperm*. Meerut: Rastogi Publication.
- Verma, V. (2010). *A text book of economic botany*. New Delhi: Emkay publications.

Suggested e-Resources:

➤ **Angiosperms: APG system of classification**

<https://academic.oup.com/botlinnean/article/181/1/1/2416499>

➤ **Angiosperms: Classification and reproduction**

<https://www.toppr.com/guides/biology/plant-kingdom/angiosperms/>

➤ **Economic botany**

<http://nsdl.niscair.res.in/jspui/bitstream/123456789/130/1/beverages.pdf>

Angiosperms Taxonomy and Economic Botany Lab

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
0	0	4	2

Learning Outcomes:

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

- Develop skills for plant identification, with reference to systematic position, morphological characters, floral formula and floral diagram.
 - Diagnose the structural features of plant organs and differentiate microscopically their tissue elements.
 - Study fiber, gum, resin, timber, spices and medicinal plants and its applications.
1. Study of locally available plants of the families mentioned in the syllabus.
 2. Study of economically important plant products as mentioned in the syllabus.
 3. Preparation of herbarium.

Suggested Books:

- Sahu, A.C. (2015). *Text book of Practical Botany*. New Delhi: Kalyani Publishers.

Cell and Tissue Culture Technology

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

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

- Virtually develop an idea of cell culture laboratory.
- To learn different techniques/methods of cell culture like primary cell culture, subculturing, cryopreservation, thawing etc. along with their applications.
- Basics of animal and plant cell culture knowledge will help them to join any of the cell culture based research institution and industry of repute besides the academics employability.
- The students can establish their own cell culture laboratory as an entrepreneur.

Section-A

- Historical background and terminologies used in cell & tissue culture.
- Basic techniques of cell and tissue culture, sterilization, aseptic tissue transfer, concept of totipotency.
- Nutritional requirement of cell *in vitro*, various types of nutrient media.
- Contamination and cytotoxicity.
- Cryopreservation and cell storage.
- Isolation of plant cells, single cell cultures and cloning.

Section-B

- Organogenesis and somatic embryogenesis, applications in agriculture, horticulture & forestry.
- Haploid production: androgenesis, gynogenesis various techniques, applications.
- Production of disease free plants by tissue culture methods.
- Protoplast isolation and culture, fusion of protoplasts.
- Somatic hybrids, selection methods, gene expression in somatic hybrids.

Section-C

- Disaggregation of animal tissue, isolation of cells, single cell culture, routine maintenance of animal cell lines.
- Cloning & selection of specific animal cell types.
- Transfection: gene transfer methods for adherent and non-adherent cell culture.
- Cell fusion: fusogen, animal somatic cell fusion and selection of cybrids.
- Animal organ culture.
- Elementary idea about animal cell culture products.

Suggested Books:

- Bhojwani, S.S. & Razdan, M.K. (1996). *Plant Tissue Culture*. USA: Elsevier Science.
- Buler, M. (2003). *Animal Cell Culture and Technology* (2nd ed.). UK: Taylor & Francis.

- Chawla, H.S. (2000). *Introduction to Plant Biotechnology*. US: Science Publishers.
- Clynes, M. (Ed.) (1998). *Animal Cell Culture Techniques*. Germany: Springer-Verlag Berlin Heidelberg.
- Davis, J.M. (2011). *Animal Cell Culture: Essential Methods*. New Jersey, USA: John Wiley & Sons Ltd.
- Freshney, R.I. (2011). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications* (6th ed.). USA: Wiley-Blackwell.
- John, R.W. (2000). *Animal Cell Culture: A Practical Approach* (3rd ed.). UK: Oxford University Press.
- Mathur, S. (2006). *Animal Cell and Tissue Culture*. India: Agrobios.
- Pollard, J.W. & Walker, J.M. (Eds.) (1990). *Animal Cell Culture*. USA: Humana Press
- Razdan, M.K. (2006). *Introduction to Plant Tissue Culture*. New Delhi, India: Oxford and IBH Pub.
- Smith, R.H (Ed.). (2013). *Plant tissue culture: Techniques and experiments*. Amsterdam: Academic Press.

Suggested e- Resources:

- **Background of Tissue Culture Technology**
<http://www.biologydiscussion.com/botany/tissue-culture/tissue-culture-definition-history-and-importance/42944>
- **Embryogenesis and organogenesis**
<https://nptel.ac.in/courses/102103016/module1/lec8/3.html>
- **Single cell cultures and cloning**
<http://www.biologydiscussion.com/botany/tissue-culture/methods-for-obtaining-single-cell-clones-from-callus-culture-plant-tissue-culture/43004>
- **Protoplasm isolation and regeneration**
<https://nptel.ac.in/courses/102103016/12>
- **Haploid plant production**
<http://www.biologydiscussion.com/plants/haploid-plants/production-of-haploid-plants-with-diagram/10700>
- **Preservation of cell lines**
<https://www.ukessays.com/essays/biology/techniques-for-cell-preservation-biology-essay.php>
- **Somatic hybridization**
<http://www.biologydiscussion.com/somatic-hybridization/somatic-hybridization-aspects-applications-and-limitations/10686>
- **Animal cell culture products**
<http://www.biologydiscussion.com/biotechnology/animal-biotechnology/applications-of-animal-cell-cultures/10457>
- **Cell Culture Technology**
https://onlinecourses.nptel.ac.in/noc17_bt21/preview

Applied Entomology and Insect Pest Management

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

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

- Comprehend role of insects in agriculture.
- Describe types of insecticides and evaluate their toxicity.
- Develop skill in insect pest management.

Section-A

- Distribution, habitat, appearance, life history, importance and control measures of house hold insects- Cockroaches and house fly. Polyphagous insects (locust; termites; white grub and red hairy caterpillar).
- Characteristic features, life cycle, nature of damage and control measures of- important insect pests of cotton; sugarcane; paddy; wheat; cereals & pulses; maize; vegetables; oil seeds; fruit trees; store grains pest and their management.

Section-B

- Classification of insecticides; Structure and mode of action of various chemical insecticides-Organochlorides; organophosphates; carbamates; pyrethroids; neonicotinoids. Insect growth regulators; Concepts of I, II and III generation of insecticides.
- Evaluation of toxicity of insecticides; toxicity parameters- LD_{50} , LC_{50} , LT_{50} , KD_{50} , ED_{50}/EC_{50} , formulation of insecticides; insect resistance, insecticidal act-1968. Insecticide poisoning- symptoms first aid and antidotes.

Section-C

- Methods of Insect Pest Management (IPM): Concepts, scope and limitations of IPM, different IPM strategies (physical; mechanical; cultural; genetic; botanical; legal/regulatory control and chemical control).
- Methods of biological control- Parasitoids; parasitic nematodes; microbial agents- baculoviruses; bacteria; fungi and protozoans. insect attractants, repellents and antifeedants.
- Industrial entomology- Apiculture, sericulture, lac culture.

Suggested Books:

- Atwal, A.S. (1986). *Agricultural Pests of INDIA and South East ASIA* (2nd ed.). New Delhi, India: Kalyani Publishers.
- Awasthi, V.B. (2009). *Introduction to General and Applied Entomology* (3rd ed.). New Delhi, India: Scientific Publishers.
- Eldridge, B. (2004) *Medical Entomology* (2nd ed.). Netherland: Springer.
- Fenemore, P.G., & Prakash, A. (2009). *Applied Entomology* (2nd ed.). New Delhi, India: New Age Publishers.
- Pedigo, L.P. (2004). *Entomology and pest management* (6th ed.). New Jersey, US: Prentice Hall Inc.
- Singh, R. (2018). *Elements of Entomology* (2nd d.). Meerut, India: Rastogi publication.

- Srivastava, K.P., & Dhaliwal, G.S. (2010). *A Text Book of Applied Entomology* Vol I & II. New Delhi, India: Kalyani Publishers.

Suggested e-Resources:

- **Insect Ecology and Integrated Pest Management**

<http://www.agrimoon.com/insect-ecology-integrated-pest-management-pdf-book/>

- **Applied Entomology**

https://www.researchgate.net/publication/327282644_A_Text-book_of_Economic_Entomology_M_Dayib

- **Chemical Insecticides**

<https://www.britannica.com/technology/insecticide>

<http://npic.orst.edu/ingred/ptype/index.html>

Bioethics and Biosafety

Max. Marks : 60
(CA: 20 + ESA: 40)

L	T	P	C
3	1	0	4

Learning Outcomes:

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

- Explain role of biotechnology in sustainable research and various ethical implications.
- Understand biosafety –objective, implementation, necessity and legislations.
- Develop preliminary understanding of Intellectual Property with emphasis on patents.

Section - A

- (i) Introduction to science, technology and society.
 - (ii) Socio-economic impacts of biotechnology.
- (i) Global biotech issues: major categories and impact.
 - (ii) Biodiversity: concept and importance, main features of Indian Biodiversity Act.
 - (iii) Traditional knowledge.
 - (iv) Access and benefit sharing (ABS): concept, convention on biological diversity and its impact on ABS, regulation of ABS and impact on developed and developing countries.
 - (v) Environmental sustainability: concept of sustainable development types and factors, significance for developed and developing countries.
- (i) Globalization : concept, impact in biotechnology.
 - (ii) Development divide.
- (i) Concept of legality, morality and ethics.
 - (ii) Concept and Principles of bioethics: expanding scope of ethics from biomedical practice to biotechnology.
 - (iii) Ethical conflicts in biotechnology: interference with nature, fear of the unknown, unequal distribution of risks and benefits of biotechnology; bioethics vs. business ethics.
 - (iv) Case studies of relevance - ethical aspects of human genome project prenatal diagnosis and xenotransplantation.

Section - B

- (i) Biosafety: concept definition of risks, hazards and various terminologies associated with hazard assessment and management.
 - (ii) Public acceptance in biotechnology (based on rationals vs subjective perception of risk and benefits).
- (i) Biotechnology and biosafety concerns at the level of individuals, institutions and country.
 - (ii) Cartagena Protocol: history conception and implementation of the protocol, impact on nations, main areas covered.
- (i) Levels of Biosafety: concept, levels and their description (plants, animals and microbes).

- (ii) General concepts: Good Lab Practices, Good Manufacturing Practices, Good Clinical Practices, Good Large Scale Practices.
 - (iii) Chemical and biological hazards: disposal and safeguards.
8. (i) Biosafety regulations in the handling of recombinant DNA processes and products in institutions and industries- India America, European Union, China and Japan.
- (ii) Biosafety assessment: A general perspective.

Section - C

9. (i) Biotechnology and food safety: The GM food debate and biosafety assessment procedures for biotech foods and related products, including transgenic food crops.
- (ii) Ecological safety assessment of recombinant organisms and transgenic crops, Case studies-golden rice, Bt cotton, flavr savr tomatoes, transgenic soybean.
10. International dimensions in biosafety:
- (i) Bioterrorism and convention on biological weapons.
 - (ii) Biosafety assessment of biotech pharmaceutical products such as drugs/ vaccines.
11. Patents: brief description, types, basic idea of patent application and procedure, farmers rights Plant breeder's rights, international union for the protection of new varieties of plants (UPOV)
12. Intellectual Property rights: definition, origin, types, Role of GATT, WTO, WIPO and TRIPS in IPR, ethical impacts of IPR, technology transfer (concept and significance) ownership and monopoly.

Recommended Books:

- Biological Safety Principles and Practices 3rd Ed: Fleming, D.A., Hunt, D.L., ASM Press, Washington.
 - Biotechnology - A Comprehensive Treatise (Vol. 12). Legal Economic and Ethical Dimensions: H.J. Rehm and G. Reed, VCH.
 - Biotechnology and Safety Assessment 3rd Ed: Thomas, J.A., Fuch, R.L. Academic Press.
- Encyclopedia of Bioethics.

Bioprocess Engineering and Technology

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

After successful completion of the course, students should be able to:

- Identify bioreactor design and differentiate between types.
- Explain kinetics of scale up and sterilization along with processes of downstreaming.
- Demonstrate large scale production of biomolecules.

Section – A

- General concept of fermentation, Types of bioreactors (CSTR, Bubble driven bioreactor, Packed bed bioreactor, Fluidized Bed bioreactor).
- Basic concept of mass balance & yield coefficient.
- Unstructured & structured growth model.
- Batch, continuous & fed batch processes with substrate utilization & product formation kinetics.
- Sterilization kinetics.

Section-B

- Volumetric mass transfer coefficient (k_La).
- Medium Rheology in bioprocesses engineering.
- Downstream processing: Bioseparation- ultrafiltration, precipitation, Cell disruption, Liquid-liquid extraction, chromatography, drying, crystallization.
- Upscaling of bioprocess.
- Enzyme immobilization & immobilized cell systems.

Section-C

- Screening, maintenance & strain improvement of industrially important microbes.
- Analysis of a few industrially important bioprocesses/products (taking into consideration- the raw material, media, organism, metabolic pathway, bioreactor, product separation and uses):
 - (i) Organic acids (acetic acid, citric acid).
 - (ii) Solvents (butanol, acetone, ethanol).
 - (iii) Enzymes (α amylase, proteases, lipase).
 - (iv) Antibiotics (penicillin, streptomycin).
 - (v) Recombinant product (humulin, erythropoietin).

Suggested Books:

- Bailey, J.E. & Ollis, D.F. (1986). *Biochemical Engineering Fundamentals* (2nd ed.). New York, USA: McGraw-Hill Education.
- Clark, D.S. & Blanch, H.W. (1997). *Biochemical Engineering*. USA: CRC Press.
- Crueger, W. & Crueger, A. (1990). *Biotechnology, A Text Book of Industrial Microbiology* (2nd ed.). U.S.: Sinauer Associates Inc.

- Shuler, M.L., & Kargi, F. (2002). *Bioprocess Engineering Basic Concepts* (2nd ed.). New Jersey, USA: Prentice Hall PTR Upper Saddle River.
- Stanbury, P.F., Whitaker, A. & Hall, S.J. (1995). *Principles of Fermentation Technology* (2nd & 3rd ed.). US: Elsevier Science Ltd.

Suggested e- Resources:

➤ **Microbial Enzymes**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5387804/pdf/BMRI2017-2195808.pdf>

➤ **Acetone-Butanol Fermentation**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4894279/pdf/fnw134.pdf>

➤ **Microbial culture fermentation**

<https://pdfs.semanticscholar.org/b4d3/7ed66ef2e37ce22ff7a3be09e3df7568fe49.pdf>

➤ **Reverse Osmosis**

<https://www.oas.org/dsd/publications/unit/oea59e/ch20.htm>

Plant Physiology and Ecology - Laboratory

A. List of Physiology experiments

1. Osmosis
 - a. Grapes and dried raisins.
 - b. Potato osmoscope and semi permeable membrane.
 - c. Plasmolysis and deplasmolysis.
2. Root pressure
 - a. An experiment on root pressure.
3. Transpiration
 - a. Ganong's potometer and Farmer's potometer
 - b. Unequal transpiration from two surfaces of a leaf
 - i. Cobalt chloride paper method.
 - ii. Four leaf method with greased surface.
 - c. Demonstration of water lifting power of transpiration (suction force).
 - d. Ringing experiment.
 - e. Study of stomata
4. Photosynthesis
 - a. Oxygen is given off during photosynthesis (Wilmott's bubbler apparatus).
 - b. Light is necessary for photosynthesis.
 - c. Chlorophyll is necessary for photosynthesis.
 - d. CO₂ is necessary for photosynthesis.
 - e. No oxygen liberation without CO₂.
 - f. RQ by Ganong's respirometer of carbohydrate, fatty seeds and *Opuntia* phylloclade.
5. Respiration
 - a. CO₂ is produced during respiration.
 - b. Loss of dry weight in respiration.
 - c. Anaerobic respiration.

B. List of Ecological experiments

1. To determine the soil temperature by soil thermometer.
 2. To measure relative humidity of the atmosphere by wet and dry-bulb thermometer or psychrometer.
 3. To determine soil texture.
 4. To test the presence of carbonate, nitrate, pH value and base deficiency in soil.
 5. To measure the light intensity.
 6. To study the structure of the plant community of an area by quadrat method and to determine the plant density, abundance and frequency (the density, abundance and frequency can be calculated from a given data in laboratory during practical examination).
 7. To determine the water holding capacity of different soils.
- A record of the experiments done during the year is to be submitted by the candidates.

Plant Physiology and Ecology

Unit 1

- Plant water relations : Importance of water to plant life; movement of water across the membranes, ascent of sap; transpiration.
- Mineral nutrition : Methods to study the availability of macro and micro elements, uptake and roles of mineral elements.
- Translocation of organic substances : General principle and mechanism.

Unit 2

- Photosynthesis : Photosynthetic pigments, factors affecting photosynthesis, mechanism of photosynthesis, role of light, carbon fixation in plants, Photophosphorylation.
- Respiration : Significance and mechanism, factors affecting respiration, release and utilization of biochemical energy, ATP synthesis.

Unit 3

- Fat Metabolism : Mechanism of synthesis and break down of fats.
- Nitrogen metabolism : Nitrate assimilation, nitrogen fixation, amino acid synthesis and nitrogen cycle.
- Growth and Development : Physiology of dormancy and seed germination, vegetative and reproductive growth, Vernalization and Photoperiodism.
- Growth regulators : Auxins, gibberellins, cytokinins, ethylene and abscissic acid, their physiological importance.

Unit 4

Ecology :

- Plant environment : Climatic, edaphic, topographic and biotic factors.
- Ecosystem : Brief concept, food chains, ecological pyramids (Pyramids of number, mass and energy), energetics, biochemical cycling.

Unit 5

- Plant communities : Structure, classification, diversity, dynamics.
- Applied ecology : Introduction to restoration ecology.
- Environmental pollution (Air, Water and Radioactive), Conservation, Plant indicators.

Books recommended :

- Plant Physiology : Devlin & Witham, Van Narst, New Delhi : East West Press, 1974
- Plant Physiology : Salisbury & Ross, Prentice Hall of India.
- Introductory Plant Physiology : Noggle & Fritz, Prentice Hall of India.
- Plant Physiology : Taiz and Zeiger.
- Introduction to Plant Physiology : W.G. Hopkins and Hunner John Wiley and Sons Inc.
- Plant Physiology : Pandey & Sinha.
- Ecology & Environment : P.D. Sharma, Rastogi Publications, Meerut.
- Fundamentals of Ecology : E.P. Odum, Natraj Publishers, Dehradun, India.
- Plant Physiology : H.N. Srivastava, Vikas Publishing House.
- Text book of Plant Ecology by Ambasht & Ambasht.

Genetic Manipulation Technology

Max. Marks: 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

After successful completion of the course, students should be able to:

- Comprehend tools and techniques used for genetic manipulation of living organisms.
- Familiarize with current genome editing techniques.
- Develop research aptitude and technical skills to secure a job in genetic engineering labs.

Section A

- Concept of the structure of DNA, enzymes as tools of genetic engineering: restriction endonucleases, methylases, DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes
- Hybridization techniques: northern, southern, south-western and far-western and colony hybridization, FISH and GISH.
- Study of protein-DNA interactions: electrophoretic mobility shift assay, DNase footprinting, methyl interference assay, chromatin immunoprecipitation.
- Protein-protein interactions using yeast two-hybrid system; phage display.

Section B

- Plasmid vectors; M13 mp vectors; PUC19 and Bluescript vectors, phagemids; Lambda vectors; Cosmids; YACs, BACs; Expression vectors (pMal; GST; pET-based vectors), Yeast vectors, Baculovirus and *Pichia* vectors, SV40 vectors, Ti and Ri vectors.
- cDNA and genomic libraries, si-RNA Technology, construction of siRNA vectors, chloroplast engineering, introduction to genome editing by CRISPR-CAS with its applications.

Section C

- Principles of PCR: primer design, fidelity of thermostable enzymes, Types of PCR – multiplex, nested, reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR; T-vectors, PCR based site specific mutagenesis, PCR in molecular diagnostics (viral and bacterial detection).
- Sequencing methods (enzymatic and chemical); automated DNA sequencing; Pyrosequencing and Next Generation Sequencing; mutation detection: SSCP, DGGE, RFLP.

Suggested Books:

- Brown, T.A. (2010). *Gene Cloning and DNA analysis: An Introduction*. Oxford: Wiley-Blackwell.
- Glick, B.R., Pasternak, J.J., & Patten C.L. (2010). *Molecular Biotechnology: Principles and applications of recombinant DNA* (4th ed). American Society for Microbiology.
- Lemonic, N.R., & Cooper, D.N. (1996). *Gene therapy*. BIOS Scientific publisher.

- Nicholl, D.S.T. (2008). *An introduction to Genetic Engineering* (3rd ed). Cambridge: Cambridge University Press.
- Primrose, S.B., Twyman R.H., & Old R.W. (2001). *Principles of Gene Manipulation* (6th ed). Wiley-Blackwell.
- Watson, J.D., Gilman, M., Witkowski J., & Zoller, M. (1992). *Recombinant DNA* (2nd ed.). W. H. Freeman publisher.

Suggested e-Resources:

- **Next Generation Sequencing**

<file:///C:/Users/all/Downloads/49602.pdf>

- **DNA sequencing- approaches**

<https://www.ncbi.nlm.nih.gov/books/NBK21117/CRISPR/>

- **CRISPR-CAS technology**

https://www.ucll.be/sites/default/files/documents/gezondheid/crispr_cas_technology_-_manetsberger.pdf

<https://www.ncbi.nlm.nih.gov/pubmed/24584096>

Construction of siRNA expression vectors

<https://www.thermofisher.com/us/en/home/references/ambion-tech-support/rnai-sirna/tech-notes/sirna-expression-vectors--with-selectable-markers.html>

- **Gene knockout and transgenic mice**

<https://www.ncbi.nlm.nih.gov/books/NBK21632/>

Microbial Ecology and Diversity

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

After successful completion of the course, students should be able to:

- Describe microbial diversity with special reference to microbial ecosystem.
- Identify various habitats of extremophiles and their mechanism of survival.
- Explain microbial interactions of relevance in environmental remediation.

Section –A

- Brief historical overview of microbial ecology and its scope, Microbial community dynamics (r and K selection, succession within microbial communities), species diversity indices, Microbial ecosystem models.
- Different types of microbial interactions (Microbe-microbe, Plant-microbe, Animal-microbe).
- Biogeochemical cycling of sulphur, iron, ammonia & hydrogen.
- Unculturable bacteria & approaches to culture, Conventional & modern methods to study microbial diversity.

Section –B

- Extremophiles: Adaptations of Psychrophiles, Acidophiles, Alkaliphiles, Hyperthermophiles, Barophiles & Osmophiles.
- Halophiles, membrane variation, electron transport.
- Methanogens & Biogas production, Rumen microbiology - action of rumen microorganisms, microbial fermentation in the rumen.
- Applications of thermophiles & extremophiles.

Section-C

- Stress response systems in microbes: Heat shock response, envelope stress response, cold shock response, starvation strategies.
- Methanotrophs and Methylotrophs.
- Bioleaching - Microbes and mechanism of Bioremediation of iron and copper ores, metal microbe interaction: biosorption, bioaccumulation, redox transformation and biomineralization.
- Catabolic pathway of recalcitrant molecule degradation and mineralization (halocarbons, nitroaromatic, petroleum hydrocarbons, pesticides).

Suggested Books:

- Atlas, R.M. & Bartha, R. (1998). *Microbial Ecology: Fundamentals and Applications* (4th ed.). UK: Pearson Education.
- Barton, L.L. & Northup, D.E. (2011). *Microbial Ecology*. Hoboken, NJ: Wiley Blackwell.
- Mitchell, R. & Gu, J.D. (Ed.). (2010). *Environmental Microbiology* (2nd ed.). Hoboken, NJ: Wiley Blackwell.
- Satyanarayan, T. & Johri, B.N. (2005). *Microbial Diversity: Current Perspectives and Potential* (1st ed.). New Delhi, India: I.K International Publishing House.

Suggested e- Resources:

- **Microbial Ecology: History & Importance**
<https://study.com/academy/lesson/microbial-ecology-history-importance.html>
- **Modern methods to study microbial diversity**
<https://www.highveld.com/microbiology/microbial-ecology.html>
- **Biogeochemical cycle, Catabolic pathway of recalcitrant molecule degradation**
<https://bit.ly/2E7X66l>
- **Microbial Ecology**
<https://onlinelibrary.wiley.com/doi/book/10.1002/9781118015841>
- **Environmental Microbiology**
<https://onlinelibrary.wiley.com/doi/book/10.1002/9780470495117>

Microbiology and Plant Pathology

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
6	0	0	6

Learning Outcomes:

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

- Understand the structure and life process of prokaryotes and virus.
- Know about sources of plant pathogens, identify symptoms & methods of studying plant diseases
- Identify the role of various microbes in food and beverage industries.

Unit-1

- Microbiology- Brief history.
- General account of bacteria- Brief classification and structure; nutrition-types, media; bacterial growth- brief idea, factors affecting growth.
- Recombination in bacteria- conjugation, transformation and transduction.
- Pure culture techniques, staining techniques- a brief idea.

Unit-2

- Techniques for sterilization.
- Preservation of microorganisms.
- General account of viruses: introduction, structure and composition.
- Replication of viruses: lytic and lysogenic cycles.
- Cultivation of viruses.

Unit-3

- Microbiology of foods and beverages: Bread making, alcoholic beverages (beer and whisky), cheese, fermented milk products, sauerkraut.
- Microbes in spoilage of food.

Unit 4

- Bacterial diseases: General symptoms and types of bacterial diseases.
 - (i) Soft rot of carrot
 - (ii) Bacterial wilt of maize
 - (iii) Brown rot of potato
 - (iv) *Citrus* canker
- Viral diseases: General symptoms, survival and transmission of plant viruses.
 - (i) Tomato leaf curl
 - (ii) Cucumber mosaic
 - (iii) Potato mosaic
 - (iv) Tobacco mosaic

Unit 5

- Fungal diseases: General symptoms and disease cycle.
 - (i) Wart disease of potato
 - (ii) Damping off
 - (iii) Green ear of bajra

- (iv) Powdery mildew on wheat
- (v) Black rust
- (vi) Smut - Wheat and bajra
- (vii) White rust
- (viii) Early blight of potato.

Suggested Books:

- Agrios, G.N. (2005). *Plant Pathology* (5th ed.). Elsevier Science.
- Alexopoulos, C.J., Mims, C.W., & Blackwell, M. (2007). *Introductory Mycology*. New York: John Wiley & Sons.
- Ananthanarayan, R., & Paniker, C.K.J. (2009). *Ananthnarayan and Paniker's Textbook of Microbiology* (9th ed). Universities Press (India) Private Limited.
- Biswas, S.B. (2009). *An Introduction to Viruses*. New Delhi: Vani Education.
- Butler, E.J. *Plant Pathology- Fungi & Diseases in Plants*. Kolkata: Thanker Spink & Co.
- Dubey, H.C. (2013). *Introduction to Fungi*. Jodhpur: Scientific Publishers.
- Dubey, R.C., & Maheshwari, D.K. (2008). *A Text book of Microbiology*. New Delhi: S. Chand and Company.
- Kumar, H.D., & Kumar S. (2001). *Modern Concepts of Microbiology*. New Delhi: Vikas Publishing House.
- Madigan, M., Martinko, J., Stahl, D., & Clark, D. (2010). *Brock Biology of Microorganisms* (13th ed.). Pearson.
- Mehrotra R.S. (2006). *Plant Pathology*. New Delhi: Tata McGraw-Hill.
- Pelczar, M.J., Chan, E.C.S., & Kreig N.R. (2008). *Microbiology*: New Delhi: Tata McGraw Hill.
- Purohit, S.S. (2009). *Microbiology - Fundamentals and Applications*. Bikaner: Agro Botanical Publishers.
- Ross, F.C. (1983). *Introductory Microbiology*. Columbus: Charles E. Merrill.
- Sharma, P.D. (2016). *Microbiology & Plant Pathology*. Meerut: Rastogi Publications
- Sharma, P.D. (2017). *Plant Pathology*. Meerut: Rastogi Publications
- Singh, R.S. (2013). *Plant Disease*. New Delhi: Oxford & IBH.
- Willey, J.M., Sherwood, L.M., & Woolverton, C.J. (2014). *Prescott's Microbiology* (9th ed). McGraw-Hill Education.

Suggested e- Resources:

- **Plant diseases: Identification and control**
<https://www.planetnatural.com/pest-problem-solver/plant-disease/>

Microbiology and Plant Pathology Lab

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
0	0	4	2

Learning Outcomes:

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

- Learn techniques for microbial isolation, purification, handling and maintenance.
 - Gain knowledge of different methods for the isolation of microbial organisms.
 - Identify the plant diseases based upon symptoms & its causal organism.
1. Knowledge of instruments and equipments used in microbiology and plant pathology.
 2. Preparation of media: PDA, NA, EMB.
 3. Isolation of soil microorganisms by Warcup method.
 4. Isolation of microorganisms from air, water and soil.
 5. Measurement of thermal death time and thermal death point of bacterial culture.
 6. Streaking techniques: Continuous and discontinuous.
 7. Bacterial staining: Simple staining, negative staining, differential staining, endospore staining.
 8. Preservation of cultures by making glycerol stock and revival of culture.
 9. Study of bacterial and viral diseases of plants mentioned in the syllabus with help of specimens (Cucumber mosaic, tobacco mosaic, brown rot of potatoes, *Citrus canker*).
 10. Study of fungal diseases in plants mentioned in the syllabus by: a) Museum specimens; b) temporary and prepared slides (Smut-wheat and bajra, early blight of potato).

Suggested Books:

- Aneja, K.R. (2003). *Experiments in microbiology, plant pathology and biotechnology*. New Age International Publishers.
- Mitra, A. (2013). *Practical manual of modern microbiology*. Mumbai: Himalaya Pub. House.

Nutrition in Diseases and Disorders

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

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

- Find out causes, clinical manifestation, preventive and therapeutic measure of disabling diseases, malabsorption syndrome and genetic defects
- explain the role of probiotics, prebiotics, functional and nano food for maintaining health
- Counsel patients to take therapeutic measure and diet modifications

Syllabus :

Section A

1. Nutrition in Cancer
 - Introduction
 - Dietary components associated with cancer
 - Nutritional care
2. Nutrition in AIDS
 - Introduction
 - Signs and symptoms
 - Transmittal routes
 - Nutritional care
3. Nutritional support in Disabling Disease
 - Rheumatoid arthritis
 - Osteo arthrits

Section B

1. Inborn Errors of Metabolism
Metabolic defect, clinical symptoms and management of -
 - Phenylketonuria
 - Galactosemia
 - Maple syrup urine disease
 - Homocysteineuria
 - Familial hypercholesterolemia
2. Nutritional management of malabsorption syndrome, food intolerance and allergy
3. Metabolism of alcohol, nutritional effects metabotism of alcohol and nutritional therapy in chronic alcoholism

Section C

1. Prebiotics, probiotics and symbiotics – Probiotics : Definition, types and relevance; Usefulness in gastro intestinal health and other health benefits; development of probiotic products; Prebiotics: Prebiotic ingredients in foods; types of prebiotics and their effects on gut microbes; health benefits of prebiotics; symbiotics.
2. Development of functional foods, use of bioactive compounds in appropriate form with protective substances and activators; Research frontiers in functional foods; delivery of immunomodulators / vaccines through

functional foods. Nutrigenomics- concept of personalized diet. Use of nanotechnology in functional food industry.

References :

1. Antia , F.P. and Abraham, P. (1997). *Clinical Dietetics and Nutrition (4th ed.)*. Delhi : Oxford university press.
2. Bamji , M.S. Rao, P.N. and Reddy, V. (1996). *Text Book of Human Nutrition*, New Delhi : Oxford & IBH Publishing Co, Pvt. Ltd.
3. Davidson , S.R., Pabsamore, J.E. and Truswell, A.S. (1984). *Human Nutrition and Dietetics*. Edinburgh : English Language Book Society and Churchill livingston.
4. Lutz Carroll A. , Mazur Erin E. & Litch Nancy A. (1997). *Nutrition and Diet Therapy,(6th ed.)*. Philadelphia : F.A. Davis Company.
5. Robinson, C.H.(1986).*Normal and Therapeutic Nutrition (17th ed.)*. NY: McMillan publishing Company.
6. Sharma, S. (2000). *Human nutrition and Meal planning*. New Delhi : Nanda Prakashan.
7. Shils, M.E., Olson, J.A. Shike. and Ross, A.C. (1999). *Modern Nutrition in Health and Disease,(9th ed.)*. Maryland : Williams & Wilkins.
8. Wardlaw, C. M. and Insel, P.M. (1993) .*Perspectives in Nutrition. (2nd ed.)* St. Louis US : Mosby College Publishing.
9. Williams, S.R. (1989). *Nutrition and Diet Therapy. (6th ed.)*. St. Louis US : Time Mirror / Mosby College Publishing.

E- resources :

- History, Nutraceuticals, Mechanism, products and application
<https://www.slideshare.net/drswaroopsoumya/prebiotics-and-probiotics-40275016>
- Different kinds of probiotics, sources and side effects
<https://www.slideshare.net/151212345/prebiotic-and-probiotic>
- Inborn errors of metabolism
<https://www.slideshare.net/Sreevarshinim/inborn-errors-of-metabolism-ppt>

Ore Genesis and Economic Geology

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
4	0	0	4

Learning Outcomes:

After the completion of this course, students should be able to:

- Describe the minerals that can be used for economic and/or industrial purposes.
- Identify and describe the precious and base metals, nonmetallic minerals and building stone.
- Explain the ore formation processes and its geological setting.
- Estimate the resource and reserves availability.

Course Content:

Section A

Introduction to Ore forming processes, Magmatic processes of mineralization, hydrothermal mineralization, oxidation and supergene enrichment. Prophyry, skarn. Fluid inclusion studies. Stratiform and stratabound ores.

Section B

Occurrence and distribution of metalliferous deposits of India: iron, manganese, aluminium, chromium, gold, nickel, lead, zinc, copper, tungsten. Indian deposits of non-metals: mica, asbestos, barytes, gypsum, graphite. Minerals used in different industries: fertilizer, paint, ceramic and cement industries.

Section C

Resources, Reserve and Classification of Ore Reserve (Russian, UNFC System and USGS/USBM Classification), Parameters for Reserve Estimation, Stages of Exploration, Ore Reserve Calculation Methods, National Mineral Policy. Mineral Concession Rules. Marine Mineral Resources and Law of Sea.

Recommended Books:

1. Evans, A.M. (1993). *Ore Geology and Industrial Minerals* (3rded.). London, UK: Blackwell.
2. Gokhale, K.Y.G.K., & Rao, T.C. (1978). *Ore deposits of India their distribution and processing*. New Delhi, India: Tata-McGraw Hill.
3. Guilbert, J.M., & Park Jr., C.F. (1986). *The Geology of Ore deposits*. New York, NY: Freeman & Co.
4. Jensen, M.L. & Bateman, A.M. (1981). *Economic Mineral Deposits* (3rded.). New York, NY: John Wiley.
5. Krishnaswamy, S. (1979). *India's Mineral resources*. New Delhi, India: Oxford & IBH.
6. Mookherjee, A. (2000). *Ore Genesis-A holistic approach*. New Delhi, India: Allied.
7. Prasad, U. (2015). *Economic Geology: Economic Mineral Deposits* (2nded.). New Delhi, India: CBS.
8. Sen, A.K., & Guha P.K. (1981). *A Handbook of Economic Geology*. Calcutta, India: Modern Book Agency.
9. Tiwari, S. K. (2010). *Ore Geology, Economic Minerals and Mineral Economics* (Vol. 1). New Delhi, India: Atlantic.

10. Tiwari, S. K. (2010). *Ore Geology, Economic Minerals and Mineral Economics* (Vol. 2). New Delhi, India: Atlantic.

Suggested e-learning materials:

1. Economic Minerals
<https://epgp.inflibnet.ac.in/ahl.php?csrno=448>
2. Indian mineral occurrence
<https://nptel.ac.in/courses/105105170/>

Plant Biotechnology

Max. Marks : 100
(CA: 40 + ESA: 60)

L	T	P	C
3	1	0	4

Learning Outcomes:

After successful completion of the course, students should be able to:

- Develop comprehensive concepts of cell and tissue culture techniques and methodology.
- Understand the basic concepts of transgenic plants and molecular pharming.
- Comprehend the basic knowledge of chloroplast engineering and edible vaccines.

Section – A

- Plant tissue culture: historical perspective, totipotency, media preparation – nutrients and plant hormones.
- Sterilization techniques, establishment of cultures – callus culture, cell suspension culture, organogenesis, somatic embryogenesis, artificial seeds.
- Micropropagation, somaclonal variation, somatic hybridization, cybrids.
- Protoplast isolation and culture, viability test, techniques of protoplast fusion, haploid production and applications.

Section – B

- Transgenic plants - basic concept and use of suitable promoters.
- Development of plants resistant to environmental stress and herbicides.
- Development of pathogen resistant plants (Virus and insect resistance).
- Overview of plant secondary metabolites, metabolic engineering, strategies for enhancement of their production in cell and tissue culture.
- Concept of plants as biofactories, molecular pharming.

Section – C

- Chloroplast engineering: techniques, advantages and application of chloroplast transgenics in production of biopharmaceuticals and introduction of agronomic traits.
- Edible Vaccines.
- Plant gene banks, germplasm collection, cryobanks.
- Biotechnology of biological nitrogen fixation: *nif* genes.

Suggested Books:

- Bhojwani, S.S., & Razdan, M K. (1996). *Plant Tissue Culture: Theory and Practice*. Nederland: Elsevier Science.
- Chawla, H.S. (2000). *Introduction to Plant Biotechnology*. USA: Science Publishers.
- Gupta, P.K. (2005). *Elements of Biotechnology*. India: Rastogi Publications.
- Singh, B.D. (2015). *Biotechnology*. Kolkata, India: Kalyani Publishers.
- Slater, A., Scott, N., & Fowler, M. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants* (2nd ed.). UK: Oxford University Press.

Suggested e-Resources:

➤ **Background of Tissue Culture Technology**

<http://www.biologydiscussion.com/botany/tissue-culture/tissue-culture-definition-history-and-importance/42944>

➤ **Embryogenesis and organogenesis**

<https://nptel.ac.in/courses/102103016/module1/lec8/3.html>

➤ **Single Cell Cultures and Cloning:**

<http://www.biologydiscussion.com/botany/tissue-culture/methods-for-obtaining-single-cell-clones-from-callus-culture-plant-tissue-culture/43004>

➤ **Protoplasm isolation and regeneration**

<https://nptel.ac.in/courses/102103016/12>

➤ **Haploid plant production**

<http://www.biologydiscussion.com/plants/haploid-plants/production-of-haploid-plants-with-diagram/10700>

➤ **Preservation of cell lines**

<https://www.ukessays.com/essays/biology/techniques-for-cell-preservation-biology-essay.php>

➤ **Somatic hybridization**

<http://www.biologydiscussion.com/somatic-hybridization/somatic-hybridization-aspects-applications-and-limitations/10686>