

**Detailed Programme Structure & Syllabus**  
**M.Sc. Environmental Science Programme Structure**

| Semester I          | Course Code          | Title of papers                               | Credit                                                  | Marks |     |
|---------------------|----------------------|-----------------------------------------------|---------------------------------------------------------|-------|-----|
| 1 <sup>st</sup> SEM | PGEVS -101N          | Ecosystem and Biodiversity Conservation       | 4                                                       | 100   |     |
|                     | PGEVS -102N          | Environmental Chemistry                       | 4                                                       | 100   |     |
|                     | PGEVS -103N          | Environmental Microbiology                    | 4                                                       | 100   |     |
|                     | PGEVS-104 N(P)       | Practical's based on PGEVS 101N,102N and 103N | 4                                                       | 100   |     |
|                     | PGBR-01N             | Basics in Research                            | 4                                                       | 100   |     |
| Credit I semester   |                      |                                               | 20                                                      | 500   |     |
| 2 <sup>nd</sup> SEM | PGEVS -106N          | Numerical and Statistical Computing           | 4                                                       | 100   |     |
|                     | PGEVS -107N          | Energy Resources and Climate Change           | 4                                                       | 100   |     |
|                     | PGEVS -108N          | Solid and Hazardous Waste Management          | 4                                                       | 100   |     |
|                     | PGEVS -109N(P)       | Practical's based on PGEVS 106,107 and 108    | 4                                                       | 100   |     |
|                     | PGED-02N             | Entrepreneurship Development                  | 4                                                       | 100   |     |
| Credit II semester  |                      |                                               | 20                                                      | 500   |     |
| 3 <sup>rd</sup> SEM | PGEVS -111N          | Water Quality and Water Treatment Technology  | 4                                                       | 100   |     |
|                     | PGEVS -112N          | Remote Sensing and GIS                        | 4                                                       | 100   |     |
|                     | PGEVS -113N          | Plant Stress and Physiology                   | 4                                                       | 100   |     |
|                     | PGEVS-114N(P)        | Practical's based on PGEVS-111N,112N and 113N | 4                                                       | 100   |     |
|                     | PGRT -03N            | Research Tools and Practices                  | 4                                                       | 100   |     |
| Credit III semester |                      |                                               | 20                                                      | 500   |     |
| 4 <sup>th</sup> SEM | Select any one group |                                               |                                                         |       |     |
|                     | Group-I              | PGEVS-116 N                                   | Geosciences and Natural Resource Management             | 4     | 100 |
|                     |                      | PGEVS-117N                                    | Atmosphere and Ocean Science                            | 4     | 100 |
|                     |                      | PGEVS-118N                                    | Environmental Impact Assessment and Management          | 4     | 100 |
|                     |                      | PGEVS -119N(P)                                | Practical's based on based on PGEVS -116N,117N and 118N | 4     | 100 |
|                     | OR                   |                                               |                                                         |       |     |
|                     | Group-II             | PGEVS-120N                                    | Environmental Toxicology & Occupational Health Hazards  | 4     | 100 |
|                     |                      | PGEVS-121N                                    | Biochemistry and Nanobiology                            | 4     | 100 |
|                     |                      | PGEVS-122N                                    | Environmental Biotechnology and IPR                     | 4     | 100 |
|                     |                      | PGEVS-123N                                    | Practical's based on based on PGEVS -120N,121N and 122N | 4     | 100 |
|                     | Compulsory paper     |                                               |                                                         |       |     |
|                     |                      | PGEVS-124N(D)                                 | Dissertation/Industrial training/Internship (Viva voce) | 4     | 100 |
| Credit IV semester  |                      |                                               | 20                                                      | 500   |     |
| Total course Credit |                      |                                               | 80                                                      | 2000  |     |

|                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                 |                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| Programme: <b>M.Sc.</b>                                                                                                                                                                                                                                                                                                                                                                        | Year: <b>2025-26</b>                                                                                                                                                                                                                                                                                                                                                                                            | Semester: <b>I</b> |
| Subject: <b>Environmental Science</b>                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                 |                    |
| Course Code: <b>PGEVS-101N</b>                                                                                                                                                                                                                                                                                                                                                                 | Course Title: <b>Ecosystem and Biodiversity Conservation</b>                                                                                                                                                                                                                                                                                                                                                    |                    |
| <b>Course Objectives:</b> <ul style="list-style-type: none"><li>➤ To understand the concept of ecosystem and its role in maintaining our natural balance.</li><li>➤ To discuss the concepts of ecology and essential ecological processes.</li><li>➤ To discuss the biodiversity, its conservation and preservation.</li><li>➤ To understand the Wildlife Protection and Ecotourism.</li></ul> |                                                                                                                                                                                                                                                                                                                                                                                                                 |                    |
| <b>Course Outcomes:</b><br>CO 1: Able to know the concept of ecosystem and ecology<br>CO 2: Gain knowledge about biogeochemical cycle<br>CO 3: Able to know the population ecology and ecological succession.<br>CO 4: Learn the biodiversity and its protection, assessment and conservation.<br>CO 5: Able to do wildlife conservation and ecotourism                                        |                                                                                                                                                                                                                                                                                                                                                                                                                 |                    |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                                                     | <b>Type of Course:</b> Core                                                                                                                                                                                                                                                                                                                                                                                     |                    |
| Max. Marks: 100                                                                                                                                                                                                                                                                                                                                                                                | Min. Passing Marks: 36                                                                                                                                                                                                                                                                                                                                                                                          |                    |
| <b>Block 1</b>                                                                                                                                                                                                                                                                                                                                                                                 | <b>Ecology and Ecosystem</b>                                                                                                                                                                                                                                                                                                                                                                                    |                    |
| Unit I                                                                                                                                                                                                                                                                                                                                                                                         | <b>Ecosystem:</b><br>Concept, types, structure and function, ecological pyramids, productivity, food chains and food webs, energy models, biogeochemical cycles.                                                                                                                                                                                                                                                |                    |
| Unit II                                                                                                                                                                                                                                                                                                                                                                                        | <b>Population Ecology:</b><br>Ecology and environment, basic concept of population ecology, study of population characteristics-size and density(concept of growth rate), dispersion, age structure, natality, mortality, biotic potential and life table population, inter and intra-specific relation among population.                                                                                       |                    |
| Unit III                                                                                                                                                                                                                                                                                                                                                                                       | <b>Community Structure and Ecological Succession:</b><br>Concept of community, characteristic of community, species diversity, dominance, distribution pattern, tropic level, community dynamics/ecological succession, causes of succession, types of succession, process of succession, monocl原因 and polyclimax theory, ecological niche, habitat, and competitive exclusion principle, ecological hierarchy. |                    |
| <b>Block 2</b>                                                                                                                                                                                                                                                                                                                                                                                 | <b>Fundaments of Biodiversity</b>                                                                                                                                                                                                                                                                                                                                                                               |                    |
| Unit IV                                                                                                                                                                                                                                                                                                                                                                                        | <b>Introduction to Biodiversity:</b><br>Concept of biodiversity, types of biodiversity, measuring biodiversity, biodiversity hotspots; hotspots in India, loss of biodiversity, factors affecting biodiversity; key stone species, species richness                                                                                                                                                             |                    |
| Unit V                                                                                                                                                                                                                                                                                                                                                                                         | <b>Extinction of Species:</b><br>Concept of extinction, types of extinctions, processes responsible for species extinction, current and future extinction rates, IUCN categories of threatened species, red book data, list of threatened flora and fauna in India, endangered and endemic species of India.                                                                                                    |                    |
| Unit VI                                                                                                                                                                                                                                                                                                                                                                                        | <b>Values of Biodiversity:</b><br>Direct/Indirect value of biodiversity, monetizing the value of biodiversity, intrinsic value, ethical and aesthetic value, anthropocentrism, biocentrism, ecocentrism and religions, intellectual value.                                                                                                                                                                      |                    |
| <b>Block 3</b>                                                                                                                                                                                                                                                                                                                                                                                 | <b>Conservation of biodiversity</b>                                                                                                                                                                                                                                                                                                                                                                             |                    |
| Unit VII                                                                                                                                                                                                                                                                                                                                                                                       | <b>Concept and Strategies:</b>                                                                                                                                                                                                                                                                                                                                                                                  |                    |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Conservation of biodiversity, national framework for biodiversity conservation, international framework for biodiversity conservation international conventions and treaties for conservation, habitat conservation plan, CBD convention                                                                                                        |
| Unit VIII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Biodiversity Conservation:</b><br>In-situ conservation, ex-situ conservation, sanctuaries, national parks, tiger reserves and biosphere reserves, formation and management of zoos and zoological parks, central zoo authority of India, captive breeding, role of government and non-governmental organizations in conservation.            |
| Unit IX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Threats to Biodiversity:</b><br>Habitat destruction, fragmentation, transformation, degradation and overexploitation, causes, impacts of pesticide, water and air pollution on biodiversity.                                                                                                                                                 |
| <b>Block 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Wildlife Protection and Ecotourism</b>                                                                                                                                                                                                                                                                                                       |
| Unit X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Introduction to Wildlife:</b><br>Man and wildlife conflict, causes of wildlife depletion; economic importance of wildlife; need for wildlife conservation, endangered flora and fauna of India, Special project for endangered species-project tiger, GIR lion project, tiger reserve project, elephant project, crocodile breeding project. |
| Unit XI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Wildlife management in India</b><br>Constitution of state board for wild life, Indian wildlife board, the wild life (protection) act 1972, hunting of wild animals to be permitted in certain cases, protected areas of wildlife, illegal hunting and trade.                                                                                 |
| Unit XII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Ecotourism:</b><br>Concept of ecotourism, ecotourism and the environment, importance of ecotourism, ecotourism resources, understanding ecotourism resource categories, ecotourism and education, ecotourism and protected areas, ecolabeling and greenbelt, impact of ecotourism in society.                                                |
| <b>Suggested Text Book Readings:</b> <ol style="list-style-type: none"> <li>1. Environmental Science, Subhas Chandra Santra, new central book agency, 3rd Edition, 2011</li> <li>2. A text Book of Environment Studies, Asthana, D. K. and Asthana, M. 2006, S. Chand &amp; Co</li> <li>3. Atmosphere, Weather and Climate, Barry, R. G. 2003, Routledge Press, UK.</li> <li>4. Ecology: Theories and Applications (4th Edition) by Peter Stiling; Prentice Hall.</li> <li>5. Biodiversity: a beginner's guide, John I. Spicer, One world Publications.</li> </ol> <b>Suggested online link:</b> <ol style="list-style-type: none"> <li>1. Principle of ecology, UGC-MOOCs SWAYAM.<br/><a href="https://ugcmoocs.inflibnet.ac.in/index.php/courses/view ug/156">https://ugcmoocs.inflibnet.ac.in/index.php/courses/view ug/156</a></li> <li>2. Environmental Science, Dr. Y. K. Singh, <a href="https://www.hzu.edu.in/bed/E%20V%20S.pdf">https://www.hzu.edu.in/bed/E%20V%20S.pdf</a></li> <li>3. Textbook for Environmental Studies, Erach Bharucha,<br/><a href="https://www.ugc.ac.in/oldpdf/modelcurriculum/env.pdf">https://www.ugc.ac.in/oldpdf/modelcurriculum/env.pdf</a></li> <li>4. Guidelines on Sustainable Eco-Tourism in Forest and Wildlife Areas 2021: <a href="https://www.mefcc.gov.in/mpforest.gov.in">MOEFCC.pdf (mpforest.gov.in)</a></li> <li>5. Biodiversity and its Conservation: <a href="https://www.aecc-evs.org/Chapter-4-Biodiversity.pdf">PK (AECC-EVS) Chapter - 4 Biodiversity.pdf (dducollegedu.ac.in)</a></li> </ol> |                                                                                                                                                                                                                                                                                                                                                 |
| This course can be opted as an elective by the students of following subjects: MA (Geography), BTS, M.Sc. (Botany), M.Sc. (Zoology)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                 |
| Suggested equivalent online courses (MOOCs) for credit transfer:<br>Biodiversity and Ecological Resources: <b><u>Biodiversity and Ecological Resources - Course (swayam2.ac.in)</u></b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                 |

|                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                              |                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| Programme: <b>M.Sc.</b>                                                                                                                                                                                                                                                                                                                                                                                                        | Year: <b>2025-26</b>                                                                                                                                                                                                                                                                                                                                                                                                                         | Semester: <b>I</b> |
| Subject: <b>Environmental Science</b>                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                              |                    |
| Course Code: <b>PGEVS-102N</b>                                                                                                                                                                                                                                                                                                                                                                                                 | Course Title: <b>Environmental Chemistry</b>                                                                                                                                                                                                                                                                                                                                                                                                 |                    |
| <b>Course Objectives:</b> <ul style="list-style-type: none"><li>➤ To discuss the atmospheric composition and its role in ecological process</li><li>➤ To discuss the ozone chemistry and its role in protection of living beings</li><li>➤ To discuss the environmental pollution and its types and abetments</li><li>➤ To discuss about different instrumental techniques used in detection of environmental sample</li></ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                              |                    |
| <b>Course Outcomes:</b><br>CO 1: Able to know the physical and chemical characteristic of atmospheric gases<br>CO 2: Learn the nature of greenhouse gases and it role in global warming<br>CO 3: Learn the chemistry of water, wastewater and industrial effluent.<br>CO 4: Gain knowledge about air and water sampling<br>CO 5: Able to do the air prevention and control of pollution                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                              |                    |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Type of Course:</b> Core                                                                                                                                                                                                                                                                                                                                                                                                                  |                    |
| Max. Marks: 100                                                                                                                                                                                                                                                                                                                                                                                                                | Min. Passing Marks: 36                                                                                                                                                                                                                                                                                                                                                                                                                       |                    |
| <b>Block 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Atmospheric Chemistry and Pollution</b>                                                                                                                                                                                                                                                                                                                                                                                                   |                    |
| Unit I                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Atmospheric composition and Pollution:</b><br>Composition of air, air pollutants, primary and secondary air pollutants, indoor/outdoor air pollution, source, sink and chemistry of air pollutants-carbon monoxide (CO), Nitrogen Oxide (NO <sub>x</sub> ), Sulphur Oxide (SO <sub>x</sub> ), hydrocarbon, and particulates matter, smog, acid rain, greenhouse and greenhouse effect, global warming potential of gases and its effects. |                    |
| Unit II                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Ozone Chemistry and Photochemical Smog:</b><br>Atmospheric ozone, formation and depletion of ozone in stratosphere, ozonein arctic region, free radicals and its role in ozone depletion, ozone depletion and climate change, Montreal protocol, Smog (London/Los Angeles), peroxyacetyl nitrate (PAN).                                                                                                                                   |                    |
| Unit III                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Sampling and Air Pollution Abatement:</b><br>Sampling of gases, adsorption and absorption of gas, types of particulate matter, collection equipment, settling chamber, cyclones, filters, electrostatic precipitator, scrubber and wet collector, control of particulate matter                                                                                                                                                           |                    |
| <b>Block 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Water Chemistry and Pollution</b>                                                                                                                                                                                                                                                                                                                                                                                                         |                    |
| Unit IV                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Properties of Water:</b><br>Structure of water molecule, chemical composition of river, ocean, lake water, chemical bonding in water, unique properties of water, water as solvent.                                                                                                                                                                                                                                                       |                    |
| Unit V                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Water pollution:</b><br>Definition of water pollution, source and types of water pollutants, Marine pollution, oil pollution, dissolved oxygen, biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved organic carbon (DOC), and total dissolve solid (TDS) and total suspended solid.                                                                                                                                  |                    |
| Unit VI                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Wastewater and Industrial Effluents</b><br>Meaning of wastewater, industrial effluent, composition of industrial effluents, sludge and activated sludge; Eutrophication, Role of soaps, detergents and phosphorus fertilizers in eutrophication; pathogenic bacteria, wastewater treatment, application of advanced oxidation processes.                                                                                                  |                    |
| <b>Block 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Soil and Noise Pollution</b>                                                                                                                                                                                                                                                                                                                                                                                                              |                    |
| Unit VII                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Soil Pollution:</b>                                                                                                                                                                                                                                                                                                                                                                                                                       |                    |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Characteristics of soil, soil chemical composition, soil pollutants and its sources, soil carbon, essential elements of soil, soil fertility, cation exchange and anion exchange capacity, exchangeable sodium percentage, significance of soil ion exchange, soil pH and acidity of soil, nitrogen cycle. |
| Unit VIII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Noise Pollution:</b><br>Noise pollution-sources; frequency, intensity and permissible ambient noise levels; effect on communication, impacts on life forms and humans; control measures.                                                                                                                |
| Unit IX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Industrial Pollution:</b><br>Chemical solvents used in dyeing, tanning, metallurgical and platinum industry, Burning fossil fuels like coal, oil, natural gas, and petroleum, heavy metals pollution.                                                                                                   |
| <b>Block 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Environmental Sampling and Control of Pollution</b>                                                                                                                                                                                                                                                     |
| Unit X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Radioactive and Thermal Pollution</b><br>Nuclear power plants based waste material, radioactive waste, biological and chemicals release from war, thermal pollution and its effects.                                                                                                                    |
| Unit XI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Instrumental Techniques:</b><br>Principle and application of atomic absorption spectrophotometer (AAS), Inductive couple plasma emission spectroscopy (ICPES), X-Ray fluorescence, Fourier transforms infrared spectroscopy (FTIR), ion selective electrode for air, water and soil sample analysis.    |
| Unit XII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Air prevention and Control of pollution:</b><br>Air (prevention & control of pollution) act 1981 as amended by amendment 1987 & rule 1982, motor vehicle act, 1988, the environment (protection) act 1986, rules 1986, the national green tribunal act 2010.                                            |
| <b>Suggested Text Book Readings:</b> <ol style="list-style-type: none"> <li>1. Environmental Science, Subhas Chandra Santra, new central book agency, 3rd Edition, 2011</li> <li>2. A text Book of Environment Studies, Asthana, D. K. and Asthana, M. 2006, S. Chand &amp; Co</li> <li>3. Environmental Chemistry, A.K. De, New Age Publisher International Pvt Ltd</li> <li>4. Textbook of Environmental Chemistry and Pollution Control, S.S.Dara and D.D. Mishra, S Chand &amp; Co Ltd</li> </ol> <b>Suggested online links:</b> <ol style="list-style-type: none"> <li>1. Environmental Science, Tom Theis and Jonathan Tomkin, OpenStax CNX, National Digital Library of India.<br/><a href="http://ndl.iitkgp.ac.in/document/N2tzeE1aWWpUMm04b2l1VVZEdSsvK09RckFlSkE0OWI3b1Flb2ZTNHFxST0">http://ndl.iitkgp.ac.in/document/N2tzeE1aWWpUMm04b2l1VVZEdSsvK09RckFlSkE0OWI3b1Flb2ZTNHFxST0</a></li> <li>2. Textbook for Environmental Studies, ErachBharucha,<br/><a href="https://www.ugc.ac.in/oldpdf/modelcurriculum/env.pdf">https://www.ugc.ac.in/oldpdf/modelcurriculum/env.pdf</a></li> <li>3. Environmental Pollution: <a href="#">Lesson 10.pmd (shivajicollege.ac.in)</a></li> <li>4. Instrumental Methods Of Analysis: <a href="#">SCY2.pdf (sathyabama.ac.in)</a></li> </ol> |                                                                                                                                                                                                                                                                                                            |
| This course can be opted as an elective by the students of following subjects: NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                            |
| Suggested equivalent online courses (MOOCs) for credit transfer: NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                            |

|                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                          |             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Programme: M.Sc.                                                                                                                                                                                                                                                                                                                                                                                  | Year: 2025-26                                                                                                                                                                                                                                                            | Semester: I |
| Subject: <b>Environmental Science</b>                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                          |             |
| Course Code: <b>PGEVS-103N</b>                                                                                                                                                                                                                                                                                                                                                                    | Course Title: <b>Environmental Microbiology</b>                                                                                                                                                                                                                          |             |
| <b>Course Objectives:</b> <ul style="list-style-type: none"><li>➤ To discuss the microbial diversity, nutrition, culture and microbial techniques</li><li>➤ To discuss about air water and soil microbes and it is role in environment</li><li>➤ To discuss the role of microbes in agriculture.</li><li>➤ To discuss the microbial diseases and its role as antibiotics substances</li></ul>     |                                                                                                                                                                                                                                                                          |             |
| <b>Course Outcomes:</b><br>CO 1: Able to know the concept of microbial growth and culture media.<br>CO 2: Learn about microbial integration and microbial techniques.<br>CO 3: Able to know the role of microbial diversity in soil, water and air.<br>CO 4: Gain knowledge about microbial degradation of organic matter.<br>CO 5: Also know about disease and antibiotics activity of microbes. |                                                                                                                                                                                                                                                                          |             |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                                                        | <b>Type of Course:</b> Core                                                                                                                                                                                                                                              |             |
| Max. Marks: 100                                                                                                                                                                                                                                                                                                                                                                                   | Min. Passing Marks: 36                                                                                                                                                                                                                                                   |             |
| <b>Block 1</b>                                                                                                                                                                                                                                                                                                                                                                                    | <b>Microbial Diversity and Microbial Techniques</b>                                                                                                                                                                                                                      |             |
| Unit I                                                                                                                                                                                                                                                                                                                                                                                            | <b>Microbial Diversity:</b><br>Modern approaches to bacterial taxonomy, polyphasic classification, general characteristics of primary domains and of taxonomic groups belonging to bacteria, archaea and Eukarya.                                                        |             |
| Unit II                                                                                                                                                                                                                                                                                                                                                                                           | <b>Culture Media and Nutrition:</b><br>Construction of culture media, types of microbial culture media, principles of microbial nutrition, microbial nutritional types and modes of nutrition in bacteria.                                                               |             |
| Unit III                                                                                                                                                                                                                                                                                                                                                                                          | <b>Microbial Techniques:</b><br>Theory and practice of sterilization, pure culture techniques, enrichment culture techniques, isolation and culture of aerobic and anaerobic bacteria, preservation and maintenance of microbial cultures.                               |             |
|                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Microbial Growth and Interaction:</b><br>Microbial growth, growth curve, measurement of growth and growth yields, synchronous growth and continuous culture, microbial interaction, positive and negative integration.                                                |             |
| <b>Block 2</b>                                                                                                                                                                                                                                                                                                                                                                                    | <b>Soil Water and Air Microbiology</b>                                                                                                                                                                                                                                   |             |
| Unit IV                                                                                                                                                                                                                                                                                                                                                                                           | <b>Soil Microbiology:</b><br>Soil as habitat for microbiology, soil microbes-algae, bacteria, actinomycetes, bacteriophage, protozoa, nematodes and fungi;microbial balance, rhizosphere and rhizoplane microorganism.                                                   |             |
| Unit V                                                                                                                                                                                                                                                                                                                                                                                            | <b>Water Microbiology:</b><br>Water as habitat for microbiology, water microbiology-fresh and marine water microbes, microbial analysis of water-coliforms test, purification of water by microbes, microorganism associated with organic matter decomposition in water. |             |
| Unit VI                                                                                                                                                                                                                                                                                                                                                                                           | <b>Microbiology of Air:</b><br>Define aeromicrobiology, aerofungi, and aeromicroflora of pharmacy, aeromicroflora of hospital and other houses, phylloplane microflora, phylloplane pathogens, characteristic of phylloplane microflora.                                 |             |
| <b>Block 3</b>                                                                                                                                                                                                                                                                                                                                                                                    | <b>Agriculture Microbiology</b>                                                                                                                                                                                                                                          |             |
| Unit VII                                                                                                                                                                                                                                                                                                                                                                                          | <b>Microbial Biofertilizers:</b>                                                                                                                                                                                                                                         |             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                             |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Microbial inoculants, inoculants carrier, production of microbial fertilizers, algae biofertilizers, cyanobacteria biofertilizers, mycorrhizal biofertilizers, and phosphorous adding biofertilizers.                                       |
| Unit VIII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Microbial Biopesticides:</b><br>Microbial insecticides, microbial herbicides, pseudomonas as bacterial insecticides, bacillus species as bacterial insecticides, virus insecticides.                                                     |
| Unit IX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Microbial degradation:</b><br>Sewage degrading microorganism, microbial degradation of petroleum, microbial degradation of xenobiotics compound, microorganism in abatement of heavy metal pollution, heavy metal tolerance in microbes  |
| <b>Block 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Microbes in Organic Matter and Microbial Diseases:</b>                                                                                                                                                                                   |
| Unit X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Microorganism of Organic Matter:</b><br>Microorganism associated with organic matter decomposition-cellulose, hemicelluloses, lignin and proteins, carbon assimilation and immobilization, factor effecting microbial community in soil. |
| Unit XI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Microbial diseases:</b><br>Bacterial and virus diseases with reference to tuberculosis, cholera, AIDS, Rabies, food born diseases.                                                                                                       |
| Unit XII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Chemotherapy/Antibiotics:</b><br>Antimicrobial agents, Antibiotics, penicillins and cephalosporins and broad-spectrum antibiotics, sulfa drugs, antifungal antibiotics                                                                   |
| <b>Suggested Text Book Readings:</b> <ol style="list-style-type: none"> <li>1. R.C. Dubey and D.K. Maaheshwari, A Textbook of Microbiology, S. Chand Publication-2013.</li> <li>2. Ian L. Pepper, Charles P. Gerba, Terry J. Gentry, A Microbiology, Academic Press-2015.</li> <li>3. K Vijaya Ramesh, Environmental Microbiology, MJP Publication-2019.</li> <li>4. P.K. Mahapatra, A Textbook of Environmental Microbiology, I K International Publishing House Pvt. Ltd-213.</li> <li>5. Barbara Kofwzan et al., Introduction To Environmental Microbiology, academic teachers from Wroclaw University of Technology, Poland</li> </ol> <b>Suggested online links:</b> <ol style="list-style-type: none"> <li>1. Introductory Microbiology, UGC-MOOCs SWAYAM.<br/><a href="https://ugcmoocs.inflibnet.ac.in/index.php/courses/view Ug/74">https://ugcmoocs.inflibnet.ac.in/index.php/courses/view Ug/74</a></li> <li>2. Soil Microbiology:<br/><a href="https://www.edouniversity.edu.ng/oerrepository/articles/mcb_313_soil_microbiology_20182019.pdf">https://www.edouniversity.edu.ng/oerrepository/articles/mcb_313_soil_microbiology_20182019.pdf</a></li> <li>3. AIR MICROBIOLOGY:<br/><a href="https://prog.lmu.edu.ng/colleges\CMS/document/books/MCB%20316%20-%20first%20NOTE.pdf">https://prog.lmu.edu.ng/colleges\CMS/document/books/MCB%20316%20-%20first%20NOTE.pdf</a></li> <li>4. Water microbiology:</li> <li>5. <a href="https://gurujistudy.com/bsc-microbiology-of-water-notes-study-material/">https://gurujistudy.com/bsc-microbiology-of-water-notes-study-material/</a></li> <li>6. AGRICULTURAL MICROBIOLOGY: <a href="https://www.rvskvv.net/images/I-Year-II-Sem_Agricultural-Microbiology_ANGRAU_20.04.2020.pdf">https://www.rvskvv.net/images/I-Year-II-Sem_Agricultural-Microbiology_ANGRAU_20.04.2020.pdf</a></li> </ol> |                                                                                                                                                                                                                                             |
| This course can be opted as an elective by the students of following subjects: NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                             |
| Suggested equivalent online courses (MOOCs) for credit transfer: <ol style="list-style-type: none"> <li>1. Applied Environmental Microbiology: <b><u>Applied Environmental Microbiology - Course (nptel.ac.in)</u></b></li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                             |

|                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                |                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|--------------------|
| <b>Course prerequisites:</b> None                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                |                    |
| <b>Programme:</b> M.Sc./M.A.                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Year:</b> I                                 | <b>Semester:</b> I |
| <b>Subject:</b> Statistics                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                |                    |
| <b>Course Code:</b> <i>PGBR-01</i>                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Course Title:</b> <i>Basics in Research</i> |                    |
| <b>Course Objectives:</b> The main objective of this course is to develop a research orientation among the scholars and to acquaint them with fundamentals of research methods, survey, Plagiarism and copyright issue. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                |                    |
| <b>Course Outcomes:</b>                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                |                    |
| <b>CO1:</b> To write a good qualitative research statement and design the research questions.                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                |                    |
| <b>CO2:</b> To know about the hypothesis, conduct the survey and a qualitative case study.                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                |                    |
| <b>CO3:</b> Able to know the Plagrisim and copyright issue for writing research paper and project.                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                |                    |
| <b>Credits:</b> 4                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Type of Course:</b> Core                    |                    |
| <b>Max. Marks:</b> 100                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Min. Passing Marks:</b> 36                  |                    |
| <b>BLOCK 1</b>                                                                                                                                                                                                          | <b>Basic of Research</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                |                    |
| Unit 1                                                                                                                                                                                                                  | <b>Introduction to Research:</b> Knowledge and the Approaches of Acquiring knowledge (deductive, inductive and scientific), Meaning of Research, Objectives of Research, Motivation in Research, Significance of Research, Importance of knowing How Research is Done?, Criteria of Good Research                                                                                                                                                                                                                                                                           |                                                |                    |
| Unit 2                                                                                                                                                                                                                  | <b>APPROACHES OF RESEARCH:</b> Types of Research, Research Approaches, Research Methods versus Methodology, Research and Scientific Method, Research Process                                                                                                                                                                                                                                                                                                                                                                                                                |                                                |                    |
| Unit 3                                                                                                                                                                                                                  | <b>DEFINING THE RESEARCH PROBLEM:</b> What is a Research Problem?, Selecting the Problem, Necessity of Defining the Problem, Technique involved in Defining a Research Problem.                                                                                                                                                                                                                                                                                                                                                                                             |                                                |                    |
| Unit 4                                                                                                                                                                                                                  | <b>RESEARCH DESIGN:</b> Need for Research Design, Features of Good Design, Important Concepts Relating to Research Design, Different Research Design, Basic Principles of Experimental Designs.                                                                                                                                                                                                                                                                                                                                                                             |                                                |                    |
| <b>BLOCK 2</b>                                                                                                                                                                                                          | <b>LITERATURE SURVEY, REVIEW, AND SYNOPSIS PREPARATION</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                |                    |
| Unit 5                                                                                                                                                                                                                  | <b>Literature Survey:</b> Introductions: Sources of information, need for reviewing literature, primary-secondary and tertiary sources, journals, abstracts, text books, Web resources, E-journals, journal access, case study alerts. Citation index, UGC infonet, E-books, Impact Factors, Search engines- Google scholar, Science Direct, SciFinder, Scopus, web of science.                                                                                                                                                                                             |                                                |                    |
| Unit 6                                                                                                                                                                                                                  | <b>Literature Review:</b> Establishing the Context, Identifying Gaps in Knowledge, Formulating Research Questions or Hypotheses, Defining Key Concepts and Terms, Selecting Research Methods, Supporting Research Design and Methodology, Evaluating Research Methods, Citing Relevant Studies, Avoiding Redundancy, Synthesizing Knowledge, Demonstrating Scholarly Engagement, Guiding the Organization of Your Research Paper, Providing a Theoretical Framework, Supporting Ethical Research, Contributing to the Research Conversation, Types of Review of literature. |                                                |                    |
| Unit 7                                                                                                                                                                                                                  | <b>Preparation of Research Synopsis:</b> The structure of synopsis- Title, Introduction, Literature Review, Research Questions or Hypotheses, Methodology, Data Collection, Data Analysis, Expected Outcomes and Significance, Timeline, References, Budget, Appendices.                                                                                                                                                                                                                                                                                                    |                                                |                    |
| <b>BLOCK 3</b>                                                                                                                                                                                                          | <b>ETHICS AND IPR</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                |                    |
| Unit 8                                                                                                                                                                                                                  | <b>Research Ethics:</b> Regulatory bodies, practices and compliances, Good Laboratory Practices (GLP), Research Ethics & Misconduct.                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                |                    |
| Unit 9                                                                                                                                                                                                                  | <b>Intellectual Property Rights:</b> Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties. Plagiarism, Patents, Fundamentals of patents, Product and process patent, Patent Treaties and Convention, process of filing patent (Search and retrieval), copyrights, geographical indications, design and layout, trademarks.                                                                                                                           |                                                |                    |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit 10                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Ethical consideration for research:</b> Informed Consent, Privacy and Confidentiality, Minimizing Harm and Risks, Beneficence, Justice and Fairness, Deception, Publication Ethics, Peer Review, Conflict of Interest, Animal Welfare, Data Management and Sharing, Community and Stakeholder Involvement, International Research Ethics.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>BLOCK 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>RESEARCH REFERENCE, REPORT AND PAPER WRITING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Unit11                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Reference Writing:</b> APA Style (American Psychological Association), MLA Style (Modern Language Association), Chicago Style, IEEE Style (Institute of Electrical and Electronics Engineers), AMA Style (American Medical Association), Harvard Style, Vancouver Style, Turabian Style, CSE Style (Council of Science Editors), Bluebook Style. Tips for writing references.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Unit12                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Report writing in academics and research:</b> Various kinds' of academic and research activities. Necessity of report writing for achievement of academic and research goals. Various kinds of reports / presentations. Characteristics of academic and research reports / presentations. Conclusions.<br><b>Scientific Writing</b> – Introduction to Technical writing, definition, types, characteristics, Report Writing, Research proposal writing.                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Unit13                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Research paper writing:</b> Choose a Topic, Conduct a Literature Review, Formulate a Research Question or Hypothesis, Plan Your Research, Gather Data, Organize Your Research, Write an Outline, Write the Introduction, Literature Review, Methodology, Results, Discussion, Conclusion, Cite Your Sources, Proofread and Edit, Formatting and References, Finding a Suitable Journal, Submit Your Paper, Peer Review and Revision, Final Proofreading.                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Block 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>RESEARCH TOOLS AND STATISTICAL METHODS</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Unit 14                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Basics of Data, Research Tools, and Types of Variables-</b> Research Tools for Data Collection- <b>Questionnaire</b> , Structured vs. Semi-structured, Open-ended and closed-ended questions, <b>Interview Schedule</b> -Face-to-face, telephonic, or digital, <b>Observation Method</b> , Participant and non-participant observation- <b>Checklist and Rating Scale</b> , Likert scales, semantic differential scales, <b>Dietary Assessment Tools</b> , 24-hour recall, food frequency questionnaire (FFQ), food diary, <b>Anthropometric Measurement Tools</b> , Weighing scale, stadiometer, measuring tape, MUAC, BMI chart. <b>Types of Data and Variables</b> -Qualitative vs. Quantitative, Nominal, Ordinal, Interval, Ratio, Dependent and Independent Variables. <b>Understanding Data Distributions</b> -Normal and skewed distributions, checking normality: Histogram, Q-Q Plot, Shapiro-Wilk test. |
| Unit 15                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Parametric Statistical Tools and Applications-</b> Descriptive Statistics (Parametric), Mean, Median, Mode, Standard Deviation, Variance, Percentiles and Z-scores, <b>Inferential Parametric Tests, t-tests</b> , One-sample t-test, Independent samples t-test, Paired samples t-test, <b>One-way ANOVA</b> , F-test, post-hoc interpretation, <b>Correlation and Regression</b> , Pearson correlation, Simple Linear Regression (assumptions, interpretation, $R^2$ ), <b>Confidence Intervals and p-values</b> , Interpretation and significance, <b>Tools Used:</b> MS Excel, SPSS, <b>Examples:</b> Comparing mean hemoglobin between groups, Predicting BMI from daily calorie intake.                                                                                                                                                                                                                      |
| Unit 16                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Non-Parametric Statistics and Risk Estimation Tools-</b> Descriptive Statistics (Non-Parametric), Median, Mode, Interquartile Range, <b>Non-Parametric Tests</b> , Chi-square Test, Test of independence using contingency tables, <b>Mann-Whitney U Test</b> , Comparison of two independent groups, <b>Wilcoxon Signed-Rank Test</b> , Paired samples, <b>Kruskal-Wallis Test</b> , Non-parametric ANOVA alternative, <b>Risk Estimation Tools</b> , Odds Ratio (OR), Use in case-control studies, Interpretation, <b>Relative Risk (RR)</b> , Use in cohort studies, 2x2 tables, Manual and SPSS calculation, <b>Tools Used:</b> SPSS, Manual calculation using examples, <b>Examples:</b> Association between junk food and obesity, Risk of anemia based on dietary habits.                                                                                                                                   |
| <b>Suggested Text Book Readings:</b>                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <ol style="list-style-type: none"> <li>1. C.R. Kothari, Gaurav Garg. <b>Research Methodology: Methods and Techniques</b>, New Age International Publishers, 2019.</li> <li>2. Kumar. R: Research Methodology: A Step-by-Step Guide for Beginners, (3<sup>rd</sup> Edition), SAGE, Inc., 2011.</li> <li>3. <a href="https://onlinecourses.swayam2.ac.in/cec22_ge28/preview">https://onlinecourses.swayam2.ac.in/cec22_ge28/preview</a></li> </ol> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

|                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                        |              |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| Programme: M.Sc.                                                                                                                                                                                                                                                                                                                                                                                                                       | Year: 2025-26                                                                                                                                                                                                                                                                                                                                                                          | Semester: II |
| Subject: <b>Environmental Science</b>                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                        |              |
| Course Code: <b>PGEVS-106N</b>                                                                                                                                                                                                                                                                                                                                                                                                         | Course Title: <b>Numerical and Statistical Computing</b>                                                                                                                                                                                                                                                                                                                               |              |
| <b>Course Objectives:</b> <ul style="list-style-type: none"><li>• To discuss the role of statistics in sampling and data management</li><li>• To discuss the descriptive statistics and analysis of variance.</li><li>• To discuss fundaments of computer and statistical software.</li></ul>                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                        |              |
| <b>Course Outcomes:</b><br>CO 1: Gain knowledge about sampling and data analysis<br>CO 2: Learn about mean, median mode and other statistical tools of data analysis and management.<br>CO 3: Abel to understand about hypothesis and hypothesis test for data analysis.<br>CO 4: Able to do regression, probability and variance analysis on data<br>CO 5: Also known to run statistical computing and R software for data analysis . |                                                                                                                                                                                                                                                                                                                                                                                        |              |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Type of Course:</b> Core                                                                                                                                                                                                                                                                                                                                                            |              |
| Max. Marks: 100                                                                                                                                                                                                                                                                                                                                                                                                                        | Min. Passing Marks: 36                                                                                                                                                                                                                                                                                                                                                                 |              |
| <b>Block 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Descriptive statistics</b>                                                                                                                                                                                                                                                                                                                                                          |              |
| Unit I                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Data and Sampling</b><br>Data and Statistical Data, Frequency Distribution, Graphical and Diagrammatical Representation, Inter-Relationships of Graphs, Introduction and Types of Sampling, Sampling Distribution.                                                                                                                                                                  |              |
| Unit II                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Descriptive Statistics:</b><br>Measure of Central Tendency, (Mean, Median, Mode), Measures of Dispersion, (Range, Mean Deviation, Standard Deviation, Variance), Coefficient of Variation, Skewness and Kurtosis                                                                                                                                                                    |              |
| Unit III                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Correlation and Regression Analysis</b><br>Scatter Diagram, Karl Pearson’s Coefficient of Correlation, Properties of Correlation Coefficient, Limits of Correlation Coefficient,Pearson’s Coefficient, Spearman’s Coefficient, Regressions and Linear Regression Model, Principle of Least Square, Regression Lines, Regression Coefficient, Properties of Regression Coefficients. |              |
| <b>Block 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Probability and Testing of Hypothesis</b>                                                                                                                                                                                                                                                                                                                                           |              |
| Unit IV                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Probability &amp; Distribution Theory:</b><br>Probability, Additive and Multiplicative Law of Probability, Conditional Probability, Probability Mass Functions, Probability Density Functions, Binomial Distribution, Poisson Distribution and Normal Distribution.                                                                                                                 |              |
| Unit V                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Theory Of Hypothesis:</b><br>Hypothesis and its Types, Signification Level, Critical Region, Degree of Freedom, P Value, Types of Error, Z-test, t-test, F-test and Chi-Square Tests with its applications.                                                                                                                                                                         |              |
| Unit VI                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>ANOVA (Analysis Of Variance):</b><br>Introduction to ANOVA, Analysis of Variance One Way and Two Way Classification, ANOVA with Missing Observation (One and Two Missing observations), Analysis of Covariance.                                                                                                                                                                     |              |
| <b>Block 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Introduction to Computer</b>                                                                                                                                                                                                                                                                                                                                                        |              |
| Unit VII                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Computer Basics:</b><br>Computer and its Characteristics, Computer Generation and Classification Problem                                                                                                                                                                                                                                                                            |              |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                              |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Solving Using Computers.                                                                                                                                                                                                                                                     |
| Unit VII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Hardware and Software:</b><br>Central Processing Unit (CPU), Memory Organization, Input And Output Device, System Software, Files Commands, Editing Commands.                                                                                                             |
| Unit IX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>MS Office:</b><br><b>Word Processing Software-</b> Microsoft Office Word, <b>Spread Sheet Software-</b> Microsoft Office Excel, <b>Presentation Software-</b> Microsoft Office-Power Point, Excel As Data Base Software.                                                  |
| Block-4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Computational analyses</b>                                                                                                                                                                                                                                                |
| Unit X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Algorithm and Flow Charts:</b><br>Introduction, Objectives And Example Of Algorithms, Characteristics Of Algorithms, Various Analyses Of Algorithms, Flow Chart And Its Characteristics.                                                                                  |
| Unit XI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Computation with MS Excel:</b><br>Function Specifically, Numeric/Mathematical Functions, Statistical Functions, Logical Function, Loop Functions, Statistical Analysis Using Excel-Descriptive Statistics, Curve Fitting, Correlation And Regression Analysis And Graphs. |
| Unit XII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Statistical Software:</b><br>Brief introduction about Statistical Software (SPSS, R etc), Basics of R, R Studio, Creation of Data File, Statistical Analysis with R                                                                                                       |
| <b>Suggested Text Book Readings:</b> <ol style="list-style-type: none"> <li>1. Introduction to Statistics, David Lane, Rice University</li> <li>2. Basic Statistics, B.L. Agrawal, New Age International Private Limited</li> <li>3. Basic Statistics, Thomas Higher Education Textbooks</li> <li>4. Computer Fundamentals : Concepts, Systems &amp; Application, Priti Sinha, Pradeep K., Sinha , BPB Publications</li> <li>5. The Book of R: Tilman M. Davies, San Francisco</li> </ol> <b>Suggested online links:</b> <ol style="list-style-type: none"> <li>1. Introduction to Descriptive Statistics: <a href="#">introduction-to-descriptive-statistics.pdf</a></li> <li>2. Descriptive Statistics: <a href="#">Slide 1 (incois.gov.in)</a></li> <li>3. Basic Probability Theory: <a href="#">46628-0 Ash 1 (illinois.edu)</a></li> <li>4. Probability Theory: <a href="https://faculty.math.illinois.edu/~r-ash/BPT/BPT.pdf">https://faculty.math.illinois.edu/~r-ash/BPT/BPT.pdf</a></li> </ol> |                                                                                                                                                                                                                                                                              |
| This course can be opted as an elective by the students of following subjects: Any one                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                              |
| Suggested equivalent online courses (MOOCs) for credit transfer:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                              |
| <ol style="list-style-type: none"> <li>1. Computer Fundamentals: <b><u>Computer Fundamentals - Course (swayam2.ac.in)</u></b></li> <li>2. Descriptive Statistics: <b><u>Descriptive Statistics - Course (swayam2.ac.in)</u></b></li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                              |

|                                                                                                                                                                                                                                                                                                                                                              |                                                   |              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|--------------|
| Programme: M.Sc.                                                                                                                                                                                                                                                                                                                                             | Year: 2025-26                                     | Semester: II |
| Subject: Environmental Science                                                                                                                                                                                                                                                                                                                               |                                                   |              |
| Course Code: PGEVS-107N                                                                                                                                                                                                                                                                                                                                      | Course Title: Energy Resources and Climate Change |              |
| <b>Course Objectives:</b> <ul style="list-style-type: none"><li>• To discuss the source of energy in nature and its role in regulation of ecosystem</li><li>• To discuss about solar radiation and energy budget</li><li>• To discuss global warming and its effect on living beings</li><li>• To discuss the climate change and policy Frameworks</li></ul> |                                                   |              |

|                                                                            |                                                                                                                                                                                                                                                                                       |
|----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Outcomes:</b>                                                    |                                                                                                                                                                                                                                                                                       |
| CO 1: Able to understanding the source of energy in nature.                |                                                                                                                                                                                                                                                                                       |
| CO 2: Understanding the concept energy and energy budget                   |                                                                                                                                                                                                                                                                                       |
| CO 3: Learn about conventional-nonconventional energy and its conservation |                                                                                                                                                                                                                                                                                       |
| CO 4: Able to learn concept of global warming and climate change           |                                                                                                                                                                                                                                                                                       |
| CO 5: Also discuss on energy polices and Indian climate panel              |                                                                                                                                                                                                                                                                                       |
| Credits: 4                                                                 | <b>Type of Course:</b> Core                                                                                                                                                                                                                                                           |
| Max. Marks: 100                                                            | Min. Passing Marks: 36                                                                                                                                                                                                                                                                |
| <b>Block 1</b>                                                             | <b>Environmental Physics</b>                                                                                                                                                                                                                                                          |
| Unit I                                                                     | <b>Introduction to environmental Physics:</b><br>Concept and scope of environmental physics with respect to human environment, built environment; laws of thermodynamics, irreversible thermodynamics and entropy, heat balance (steady and transient).                               |
| Unit II                                                                    | <b>Solar Radiation:</b><br>Electromagnetic radiation, thermal regulation in buildings- thermal insulation, thermal conduction effects, convection effects, radiation effects, u-values, energy flow diagram to the earth.                                                             |
| Unit III                                                                   | <b>Energy Budget:</b><br>Energy use and efficiency in buildings. Energy losses, calculation of energy losses, energy gains, Air regulation in buildings, heat pumps, condensation.                                                                                                    |
| <b>Block 2</b>                                                             | <b>Energy Resources</b>                                                                                                                                                                                                                                                               |
| Unit IV                                                                    | <b>Concept of Energy:</b><br>Definition and units of energy, types of energy resources, conventional-nonconventional, renewable-nonrenewable energy resources, energy tools and techniques of energy conservation, origin and time scale of fossil fuels production.                  |
| Unit V                                                                     | <b>Energy Flow Models:</b><br>Basic or universal model, energy flow models of aquatic ecosystems and terrestrial ecosystem, comparison of energy flow in different ecosystems, Lindeman's trophic dynamic aspect.                                                                     |
| Unit VI                                                                    | <b>Politics of Energy Policy:</b><br>Political choices in energy policy globally and in the Indian context (historical and contemporary case studies), domestic and international energy policy, energy diplomacy and bilateral ties of India with her neighbor.                      |
| <b>Block 3</b>                                                             | <b>Climate Change and Global Warming</b>                                                                                                                                                                                                                                              |
| Unit VII                                                                   | <b>Introduction to Climate Change:</b><br>Definition, scope and facts of climate change, earth energy budget, composition and thermal structure of atmosphere, origin and types of wind, wind speed & direction, weather and climate, temperature, pressure, precipitation, humidity. |
| Unit VIII                                                                  | <b>Monsoons:</b><br>Definition of monsoon, winter, summer and rainy season of Indian monsoon, cyclones of the Indian region; El-Nino, La Nina, and IOD and their impacts.                                                                                                             |
| Unit IX                                                                    | <b>Greenhouse Effect and Global Warming:</b><br>Greenhouse gases causes and effects, sources and sinks of greenhouse gases; urban heat islands; ozone layer depletion and recovery, issues and remedies; ground level ozone and air pollution; global dimming, carbon footprint.      |
| <b>Block 4</b>                                                             | <b>Climate Change and Policy Frameworks</b>                                                                                                                                                                                                                                           |
| Unit X                                                                     | <b>Impacts of Global Climate Change:</b><br>Increased surface mean temperature, insect outbreaks, vector borne/zoonotic diseases, forest fire, reduced water availability, loss of biodiversity and extinction of species, sea level rise, and food security.                         |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit XI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Climate Change and Policy Frameworks:</b><br>History of international climate change policies, united nation framework, convention on climate change (UNFCCC), intergovernmental panel on climate change (IPCC). |
| Unit XII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Indian Climate Panel:</b><br>Ministry of environment, forests & climate change (MOEF&CC), national action plan on climate change (NAPCC), agenda 21, the Kyoto protocol, Paris agreement.                        |
| <b>Suggested Text Book Readings:</b> <ol style="list-style-type: none"> <li>1. Environmental Science, Subhas Chandra Santra, new central book agency, 3rd Edition, 2011</li> <li>2. Non conventional Energy Resources, D.S. Chauhan, New Age International.</li> <li>3. Renewal Energy Technologies: A Practical Guide for Beginners, C.S. Solanki, PHI Learning.</li> <li>4. Advances in Energy System and Technology, Peter Auer, Vol. 1 &amp; II Edited by Academic Press. Godfrey, “ Renewable Energy Power For A Sustainable Future, Boyle, Oxford University Press.</li> <li>5. Introduction to Energy and Climate , Developing a Sustainable Environment, Julie Kerr, Taylor &amp; Francis eBooks</li> </ol> <b>Suggested online links:</b> <ol style="list-style-type: none"> <li>1. Solar radiation: 1511327362Paper7_EnergyEnv_module_2_etext-Solarradiation.pdf</li> <li>2. Sun as source of energy: 1522993850Paper7__module_1_etext.pdf</li> <li>3. Renewable energy resource: 1522993850Paper7__module_1_etext.pdf</li> <li>4. Energy flow model in ecosystem<br/>:http://www.dspmuranchi.ac.in/pdf/Blog/aksinghdspmuranchiacinA13.pdf<br/>Introductory e-Course on Climate Change:<br/>file:///C:/Users/HP/Downloads/Introductory%20eCourse%20on%20Climate%20Change_Syllabus.pdf</li> </ol> |                                                                                                                                                                                                                     |
| This course can be opted as an elective by the students of following subjects: NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                     |
| <b>Suggested equivalent online courses (MOOCs) for credit transfer: NA</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                     |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                    |              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|--------------|
| Programme: M.Sc.                                                                                                                                                                                                                                                                                                                                                                                                                                 | Year: 2025-26                                      | Semester: II |
| Subject: Environmental Science                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                    |              |
| Course Code: PGEVS-108N                                                                                                                                                                                                                                                                                                                                                                                                                          | Course Title: Solid and Hazardous Waste Management |              |
| <b>Course Objectives:</b> <ul style="list-style-type: none"><li>• To discuss different types of waste generated from different sources in natural habitat</li><li>• To discuss sources risk and management of municipal solid waste, its characterization reuse</li><li>• To discuss characterization, handling and management of medical and hazardous waste</li><li>• To know how to use, reuse and recycle of solid and other waste</li></ul> |                                                    |              |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                             |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Outcomes:</b><br>CO 1: Able to know the types and characteristic of solid waste generated from different sources.<br>CO 2: Learn about the industrial hazardous waste and its characteristics<br>CO 3: To know how to handling and manage the medical waste in hospital and dumping site<br>CO 4: Able to know the concept reduce recycling and reuse of waste materials<br>CO 5: Learn to handling and management of hazardous waste |                                                                                                                                                                                                                                                             |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Type of Course:</b> Core                                                                                                                                                                                                                                 |
| Max. Marks: 100                                                                                                                                                                                                                                                                                                                                                                                                                                 | Min. Passing Marks: 36                                                                                                                                                                                                                                      |
| <b>Block 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Municipal Solid Waste</b>                                                                                                                                                                                                                                |
| Unit I                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Introduction of Solid waste:</b><br>Definition of waste, sources and generation of solid waste, their classification and chemical composition, waste characterization, impact of solid waste on environment, human and plant health.                     |
| Unit II                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Municipal and Industrial Solid Waste:</b><br>Definition, sources and generation of municipal solid waste, their classification, composition of municipal solid waste (MSW), composition and state of municipal solid waste in India.                     |
| Unit III                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Disposal of Solid Wastes:</b><br>Segregation and sorting, various methods for solid waste disposal, incinerations, sanitary landfill, advantages and disadvantages of sanitary land fill.                                                                |
| <b>Block 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Hazardous and Biomedical Waste</b>                                                                                                                                                                                                                       |
| Unit IV                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Hazardous Waste:</b><br>Definition, sources, classification of hazardous waste, characterization of hazardous waste, collection and segregation, treatment and disposal.                                                                                 |
| Unit V                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Hazardous Waste Treatment Methods:</b><br>Physical and chemical hazardous waste treatment methods, thermal treatment methods, Biological treatment of hazardous wastes.                                                                                  |
| Unit VI                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Biomedical wastes:</b><br>Definition, sources, classification, collection and segregation of biomedical waste, Biomedical Wastes Handling Rules, treatment and disposal of biomedical waste, standards for treatment and disposal of bio-medical wastes. |
| <b>Block 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Radioactive Waste and Waste Recycling</b>                                                                                                                                                                                                                |
| Unit VII                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Radioactive and Plastic Wastes:</b><br>Definition, sources, classification, collection, segregation, treatment and disposal of radioactive waste, plastic waste-source, classification and disposal, microplastic.                                       |
| Unit VIII                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>E-Waste:</b><br>Concept of e-waste, types and source of e-waste, collection strategy of e-waste, treatment of e-waste, recycle, reduce and reuse of e-waste, e-waste management in India.                                                                |
| Unit IX                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Resource Recovery:</b><br>4R- reduce, reuse, recycle and recover of waste, biological processing-composting, anaerobic digestion, aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment.    |
| <b>Block 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Waste Management Handling and Rules</b>                                                                                                                                                                                                                  |
| Unit X                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Solid Waste Management:</b><br>Solid waste management rules 2016, evolution of SWM rules in India, municipal solid wastes (management and handling) rules 2000, criteria for waste to energy process, plastic waste management rules 2016.               |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit XI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Hazardous and Medical Wastes Management:</b><br>Hazardous wastes management and handling rules 1989, hospital waste management, bio-medical waste (management and handling) rules 1998.                                       |
| Unit XII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>E-Waste Management:</b><br>Procedure for storage of e-waste, e-waste management rules 2016, e-waste regulation in India, state government for the management of waste, procedure for authorization for management of e-waste. |
| <b>Suggested Text Book Readings:</b> <ol style="list-style-type: none"> <li>1. Waste treatment and disposal, Williams, Paul T. John Wiley Publishers, 2013.</li> <li>2. E-waste: Implications, regulations and management in India and Current global best practices, TERI press, Johri, Rakesh.</li> <li>3. Bio- medical waste management, Sahai, Sushma, APH Publishing.</li> <li>4. Electronic waste management, design, analysis and application, R E Hester ,Cambridge Royal Society of Chemistry</li> <li>5. Solid and Hazardous Waste Management, Rao, M.N. and Sultana ,BS Publications, Hyderabad</li> </ol> <b>Suggested online link:</b> <ol style="list-style-type: none"> <li>1. E-waste management:<br/> <a href="https://www.epa.gov/sites/default/files/2014-05/documents/india.pdf">https://www.epa.gov/sites/default/files/2014-05/documents/india.pdf</a> </li> <li>2. Municipal Waste (Management and Handling) Rules:<br/> <a href="1519297109paper11_module_37_etext.pdf">1519297109paper11_module_37_etext.pdf</a> </li> <li>3. Medical Waste Management:<br/> <a href="https://www.icrc.org/en/doc/assets/files/publications/icrc-002-4032.pdf">https://www.icrc.org/en/doc/assets/files/publications/icrc-002-4032.pdf</a> </li> <li>4. Solid waste composting:<br/> <a href="1511177780Paper_11_module_26_yoga_etext.pdf">1511177780Paper_11_module_26_yoga_etext.pdf</a> </li> <li>5. Composition of solid waste:<br/> <a href="1511174041Paper_11_module_5_yoga_etext.pdf">1511174041Paper_11_module_5_yoga_etext.pdf</a> </li> </ol> |                                                                                                                                                                                                                                  |
| This course can be opted as an elective by the students of following subjects: NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                  |
| Suggested equivalent online courses (MOOCs) for credit transfer: <ol style="list-style-type: none"> <li>1. Solid and Hazardous Waste Management: <b><u>Solid and Hazardous Waste Management - Course (swayam2.ac.in)</u></b></li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                  |

|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                      |
|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| <b>Course prerequisites:</b> None |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                      |
| <b>Programme:</b> M.Sc./M.A.      | <b>Year:</b> I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Semester:</b> III |
| <b>Subject:</b> Mathematics       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                      |
| <b>Course Code:</b> PGED-02       | <b>Course Title:</b> Entrepreneurship Development                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                      |
| <b>Credits:</b> 4                 | <b>Type of Course:</b> Core                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                      |
| <b>Max. Marks:</b> 100            | <b>Min. Passing Marks:</b> 36                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                      |
| Unit 1                            | <b>Entrepreneurship</b> Introduction, Meaning, Evolution & Concept Of Entrepreneurship, Nature Of Entrepreneurship, Importance Of Entrepreneurship, Elements Of Entrepreneurship<br>Characteristics Of Entrepreneurship, Need Of Entrepreneurship, Functions Of Entrepreneurship<br>Types Of Entrepreneurship, Merits Of Entrepreneurship, Demerits Of Entrepreneurship, Entrepreneurship And Environment<br>The Need Of Entrepreneurship For Indian Economy ,Introduction, Views Of Leading Thinkers, Drucker's Views On Entrepreneur Walker's Views On Entrepreneur. |                      |
| Unit 2                            | <b>Entrepreneur</b> Meaning, Concept, Characteristics Of An Entrepreneur Qualities Of Entrepreneur, Difference Between Entrepreneurship And Entrepreneur, Difference Between Entrepreneur, Intrapreneur And Manager, Difference Between Entrepreneurship And Intrapreneurship                                                                                                                                                                                                                                                                                          |                      |
| Unit 3                            | <b>Functions And Types Of Entrepreneur</b> Introduction, Basic Functions Of An Entrepreneur, Process To Setup An Enterprise, Difference Between Managerial Functions And Entrepreneurial Functions Of An Entrepreneur, Types Of Entrepreneurs,                                                                                                                                                                                                                                                                                                                         |                      |
| Unit 4                            | <b>Theories Of Entrepreneurship</b> Introduction, Economic Theories, Neoclassical Economic Theories Of Entrepreneurship , Sociological Theories Of Entrepreneurship, Psychological Theories Of Entrepreneurship, Cultural Theories Of Entrepreneurship                                                                                                                                                                                                                                                                                                                 |                      |
| Unit 5                            | <b>Entrepreneurship Development Programme:</b> Introduction, Evolution And Concept Of Entrepreneurship Development Programme , Meaning, Features Of Entrepreneurship Development Programme , Need Of Entrepreneurship Development Programme , Objectives Of Entrepreneurship Development Programme , Formulation Of Entrepreneurship Development Programme , Outline Of Entrepreneurship Development Programme , Achievements Of Entrepreneurship Development Programme                                                                                                |                      |
| Unit 6                            | <b>Entrepreneurship Development In India:</b> Meaning, Sustainable Entrepreneurship Development, Phases Of Entrepreneurship Development In India, Emergence Of Entrepreneurial Class In India, Locational Mobility Of Entrepreneurs, The Key Factors Influencing The Mobility Of Entrepreneurs , Entrepreneurial Performance In India, Entrepreneurship Development Cycle, Institutions For Entrepreneurship Development                                                                                                                                               |                      |
| Unit 7                            | <b>Women Entrepreneurship:</b> Introduction, Meaning, Characteristics Of Women Entrepreneurship, Factors Affecting The Need For Women Entrepreneurship, Problems Of Women Entrepreneurs, Remedies/ Overcoming/Solutions To The Problems Of Women Entrepreneurs, Steps To Promote Women Entrepreneurs, Traits Of Successful Women, Benefits Of Women Entrepreneurship                                                                                                                                                                                                   |                      |
| Unit 8                            | <b>Promotion Of Ventures:</b> Meaning And Concept Of Projects, Characteristics Of Project, Types Of Projects, The Boundaries Of A Project, Project Life Cycle – Stages, Success Of A Project, Implementation Of A Project, Benefits Of Project Management, Project Management, .Task Management, Difference Between Task Management And Project Management , Uses Of Project Management And Task                                                                                                                                                                       |                      |

|         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|         | Management, Project Identification, Identification Stage Diagram, Formulation And Report, Project Appraisal, Product Selection And Technique, <b>Criteria And Factors To Be Considered In New Product Selection Stages, Phases Involved In New Product Selection Exercise</b>                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Unit 9  | <b>Project Management:</b> Introduction, Meaning And Concept Of A Project, Characteristics Of A Project, Importance Of Project Management, Tools And Techniques Of Project Management, Classification Of Project, Project Life Cycle And Its Phases, The Project Manager, Roles And Responsibilities Of Project Manager                                                                                                                                                                                                                                                                                                                                                                                          |
| Unit 10 | <b>Raising Funds:</b> Introduction, Concept & Relevance Of Finance For The Entrepreneur, Choices Between Sources Of Financial Capital, Sources Of Funds, The Advantages And Disadvantages Of The Different Sources Of Finance, Steps In Managing Finance, Objectives Of Financial Planning For The Entrepreneur                                                                                                                                                                                                                                                                                                                                                                                                  |
| Unit 11 | <b>Legal Requirements For Establishment Of New Business Unit:</b> Introduction, Formalizing A Business Structure And Founders Agreement, . Applying For Business Licenses, Understanding Taxation And Accounting Laws. Adhering To Labour Law. Ensuring Protection Of Intellectual Property. Ensuring Effective Contract Management. Details About Winding Down The Business                                                                                                                                                                                                                                                                                                                                     |
| Unit12  | <b>Financial Institution's Aid To Entrepreneurs</b><br>Introduction, Assistance Of Financial Institutions To Entrepreneurs, Comprehensive Promotion Structure Of MSME Sector, Financial Institutions Supporting And Assisting Small Scale Industries (SSI) In India                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Unit13  | <b>Network Analysis</b><br>Meaning And Concept Of Network Analysis, Importance Of Network Analysis/Network Technique, Classification Of Network Techniques, Programme Evaluation And Review Technique (PERT), Procedure Followed In PERT ,Advantages Of Pert ,Limitations Of Pert ,Critical Path Method (CPM): ,Identification Of The Critical Path, Advantages Of Critical Path Method ,Limitations Of CPM ,Similarities Between Pert And CPM, Comparison Between Pert And CPM ,Differences Between PERT And CPM<br>Financial Support System: Forms of Financial support, Long term and Short term financial support, Sources of Financial support, Development Financial Institutions, Investment Institutions |
| Unit14  | <b>Marketing Assistance To Entrepreneurs</b><br>Introduction, Meaning, Types Of Markets Available To An Entrepreneur, Traditional Marketing, Entrepreneurial Marketing, Differences Between Traditional And Entrepreneurial Marketing                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Unit15  | <b>Entrepreneurship Development: Intellectual Property Rights And MSME</b><br>Introduction, IPR And MSME's, Patents ,The Patent Process, Types Of Patents, Who Can File For A Patent?, Trademarks, Types Of Trademarks, Registration Of Trademark, Copyrights ,Objectives Of Copyrights, Geographical Indications ,Industrial Designs ,Trade Secrets ,Integrated Circuits, Protection Of New Plant Variety, Need Of IPR For MSME                                                                                                                                                                                                                                                                                 |
| Unit16  | <b>Small Business</b><br>Introduction, Meaning Of Small Business, Types Of Small Business, Nature Of Small Business, Characteristics Of Small Business Enterprises, Objectives Of Small Business, Importance Of Small Business, Process Of Establishing Small Business,                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Unit 17 | <b>Project Budgeting/Capital Budgeting</b><br>Introduction, Meaning And Definition Of Project/Capital Budgeting, Features Of Capital Budgeting, Importance And Need Of Capital Budgeting, Types Of Capital Expenditure, Factors Affecting Capital Investment Decisions                                                                                                                                                                                                                                                                                                                                                                                                                                           |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                      |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit 18                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Project Control</b><br>Introduction, Control Process, Scope Of Project Control, Techniques Of Schedule Control ,Techniques Of Cost Control                                                                                                                                                        |
| Unit 19                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Entrepreneurial Consultancy</b><br>Meaning, Entrepreneurial Consultancy: Process And Methods, Motives Or Reasons For Using Advisory Services, Approaches To Modern Ounselling, Marketing Counselling                                                                                              |
| Unit 20                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>E Commerce And Entrepreneurship</b><br>Introduction, Meaning And Concept Of E-Commerce , Approaches Of E-Commerce , Relevance Of E-Commerce , Advantages Of E-Commerce, Disadvantages Of E-Commerce, Difference Between Traditional Commerce And E-Commerce                                       |
| Unit 21                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Planning Of Capital Structure</b><br>Introduction, Meaning Of Capital Structure, Types Of Capital Structure, Importance Of Capital Structure, Factors Determining Capital Structure, Capital Gearing, Planning Of Capital Structure, Optimal Capital Structure, Determinants Of Capital Structure |
| <b>Suggested Text Book Readings:</b> <ol style="list-style-type: none"> <li>1. <u>C.R. Kothari, Gaurav Garg.</u> Research Methodology: Methods and Techniques, New Age International Publishers, 2019.</li> <li>2. Kumar. R: Research Methodology: A Step-by-Step Guide for Beginners, (3<sup>rd</sup> Edition), SAGE, Inc., 2011.</li> <li>3. <a href="https://onlinecourses.swayam2.ac.in/cec22_ge28/preview">https://onlinecourses.swayam2.ac.in/cec22_ge28/preview</a></li> </ol> |                                                                                                                                                                                                                                                                                                      |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                             |               |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Programme: M.Sc.                                                                                                                                                                                                                                                                                                                                                                                                                                               | Year: 2025-26                                                                                                                                                                                                               | Semester: III |
| Subject: Environmental Science                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                             |               |
| Course Code: PGEVS-111N                                                                                                                                                                                                                                                                                                                                                                                                                                        | Course Title: Water Quality and Water Treatment Technology                                                                                                                                                                  |               |
| <b>Course Objectives:</b> <ul style="list-style-type: none"><li>• To discuss the properties of water and water quality estimation</li><li>• To discuss the wastewater treatment and management</li><li>• To discuss the various methods of waste water treatment</li></ul>                                                                                                                                                                                     |                                                                                                                                                                                                                             |               |
| <b>Course Outcomes:</b> <ul style="list-style-type: none"><li>• CO 1: Able to know the physiochemical properties of water</li><li>• CO 2: Able to know characteristics of waste water, sewage and sludge.</li><li>• CO 3: Learn to preliminary, secondary treatment process of waste water</li><li>• CO 4: learn about methodology of ion exchange and disinfection for waste water</li><li>• CO 5: Also known the water born disease and water acts</li></ul> |                                                                                                                                                                                                                             |               |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Type of Course:</b> Core                                                                                                                                                                                                 |               |
| Max. Marks: 100                                                                                                                                                                                                                                                                                                                                                                                                                                                | Min. Passing Marks: 36                                                                                                                                                                                                      |               |
| <b>Block 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Water Properties and Wastewater</b>                                                                                                                                                                                      |               |
| Unit I                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Properties of Water:</b><br>Structure of water molecule, chemical composition of water, chemical bonding in water unique properties of water, water on earth, water cycle, water as solvent, scarcity of water in India. |               |
| Unit II                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Water Quality Estimation:</b>                                                                                                                                                                                            |               |

|                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                              | Water quality index, water quality standard in India, physiochemical properties of water, pH, Dissolve oxygen (DO), Chemical Oxygen Demand (COD), biological oxygen demand (BOD, Total Dissolve solid (TDS), turbidity, nitrate, sulphate and chloride.                                                              |
| Unit III                                                                                                                                                                                                                                                                     | <b>Wastewater, Sludges and Sewage:</b><br>Definition of wastewater and sludges, domestic wastewater, industrial wastewater, activated sludge, characteristics and quantities of waste sludges, physical, chemical & biological characteristics of sewage, criteria for selection of site for sewage treatment plant. |
| <b>Block 2</b>                                                                                                                                                                                                                                                               | <b>Sewage Treatment:</b>                                                                                                                                                                                                                                                                                             |
| Unit IV                                                                                                                                                                                                                                                                      | <b>Preliminary Treatment:</b><br>Screenings, sedimentation, Grit chamber, and Skimming tanks, primary treatment- primary sedimentation – description & working.                                                                                                                                                      |
| Unit V                                                                                                                                                                                                                                                                       | <b>Secondary Treatment:</b><br>Activated sludge, sludge process, trickling filters, natural biological treatment systems, wastewater stabilization ponds, anaerobic ponds, facultative ponds, anaerobic ponds, contact beds.                                                                                         |
| Unit VI                                                                                                                                                                                                                                                                      | <b>Low Cost Waste Treatment:</b><br>Oxidation ponds, Oxidation ditches, Activated Lagoon, Anaerobic lagoons and Septic tank.                                                                                                                                                                                         |
| <b>Block 3</b>                                                                                                                                                                                                                                                               | <b>Wastewater Treatment</b>                                                                                                                                                                                                                                                                                          |
| Unit VII                                                                                                                                                                                                                                                                     | <b>Coagulation and Precipitation:</b><br>Coagulation- flocculation, primary coagulants, type of coagulants, mechanism of coagulation, coagulation control test, precipitation, metals removal, removal of fats, oils and greases.                                                                                    |
| Unit VIII                                                                                                                                                                                                                                                                    | <b>Filtration:</b><br>Filtration, slow sand filter, rapid sand filter types of filtration, vacuum filtration, membrane filtration, types of membranes.                                                                                                                                                               |
| Unit IX                                                                                                                                                                                                                                                                      | <b>Ion Exchange and Disinfection of Water:</b><br>Ion exchange, types of ion exchangers, natural ion exchange, synthetic ion exchangers, cation-exchange resins, disinfection of water - methods of disinfection – chlorination.                                                                                     |
| <b>Block 4</b>                                                                                                                                                                                                                                                               | <b>Water Resource and Management</b>                                                                                                                                                                                                                                                                                 |
| Unit X                                                                                                                                                                                                                                                                       | <b>Water Quality and its Management:</b><br>Drinking water quality and water quality standard, agencies for setting water quality standards, need for management of water quality, factors affecting water quality, steps for water quality management, surface and ground water quality.                            |
| Unit XI                                                                                                                                                                                                                                                                      | <b>Waterborne Diseases:</b><br>Define waterborne disease, name and characteristics of waterborne diseases, symptoms of water born disease, prevention and treatment of waterborne diseases.                                                                                                                          |
| Unit XII                                                                                                                                                                                                                                                                     | <b>Water Acts:</b><br>Water (prevention & control of pollution) Act, 1974 as amended by amendment 1978 & rules 1975, Environment protection issues and problems, international & national efforts for environment protection.                                                                                        |
| <b>Suggested Text Book Readings:</b>                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                      |
| <ol style="list-style-type: none"> <li>1. Environmental Science, Subhas Chandra Santra, new central book agency, 3rd Edition, 2011</li> <li>2. Water &amp; Waste Water Technology, Hammer M.J. &amp; Hammer, Jr. M.J. , Prentice Hall of India Pvt Ltd New Delhi.</li> </ol> |                                                                                                                                                                                                                                                                                                                      |

3. Waste Water Engineering, Treatment. Disposal & reuse, Metcalf & Eddy, McGraw
4. Water pollution, Rico D.P.S, IX, WIT Press UK
5. Principles of water quality management, Eckenfelder

**Suggested online links**

1. Properties of Water: [Ch3-4Water&O-Chem.ppt \(sdsu.edu\)](#)
2. Properties of Water: [properties-of-water-worksheet \(baymeadowscharter.org\)](#)
3. Water Quality Analysis Laboratory Methods: [Microsoft PowerPoint - LSD-NEERI-Water Quality Analysis \(mpcb.gov.in\)](#)
4. Water Quality Assessment And Monitoring: [Water.pdf \(iitk.ac.in\)](#)
5. Water Quality Standards: [Microsoft Word - CHE P4 M8 e-Text.docx \(inflibnet.ac.in\)](#)
6. Wastewater Treatment Processes: [Microsoft PowerPoint - Sep12 WW \[Compatibility Mode\] \(iitd.ac.in\)](#)

This course can be opted as an elective by the students of following subjects: NA

Suggested equivalent online courses (MOOCs) for credit transfer:

Wastewater Treatment and Recycling: [https://onlinecourses.nptel.ac.in/noc19\\_ce32/preview](https://onlinecourses.nptel.ac.in/noc19_ce32/preview)

|                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                  |               |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Programme: M.Sc.                                                                                                                                                                                                                                                                                                                                                                                                             | Year: 2025-26                                                                                                                                                                                    | Semester: III |
| Subject: Environmental Science                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                  |               |
| Course Code: PGEVS-112N                                                                                                                                                                                                                                                                                                                                                                                                      | Course Title: Remote Sensing and GIS                                                                                                                                                             |               |
| <b>Course Objectives:</b> <ul style="list-style-type: none"><li>To discuss the concept of remote sensing and image interpretation</li><li>To discuss the atmospheric window source of energy for remote sensing</li><li>To discuss about platform, sensor and application of remote sensing</li><li>To discuss the concept of global position system and its components</li></ul>                                            |                                                                                                                                                                                                  |               |
| <b>Course Outcomes:</b> <ul style="list-style-type: none"><li>CO 1: Learn about concept of remote sensing</li><li>CO 2: Able to know electromagnetic radiation and its role in remote sensing.</li><li>CO 3: Learn about device like platform, satellite and sensor used in remote sensing</li><li>CO 4: Able to know image interpretation and data processing</li><li>CO 5: Also learn about GIS and its handling</li></ul> |                                                                                                                                                                                                  |               |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Type of Course:</b> Core                                                                                                                                                                      |               |
| Max. Marks: 100                                                                                                                                                                                                                                                                                                                                                                                                              | Min. Passing Marks: 36                                                                                                                                                                           |               |
| <b>Block 1</b>                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Remote Sensing and Image interpretation</b>                                                                                                                                                   |               |
| Unit I                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Concept of remote sensing:</b><br>History, concept and principle of remote sensing, process and characteristics of remote sensing system, element of remote sensing, types of remote sensing, |               |

|                |                                                                                                                                                                                                                                   |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                | advantages and limitations.                                                                                                                                                                                                       |
| Unit II        | <b>Concept of Electromagnetic Radiation (EMR):</b><br>EM radiation and EM spectrum, laws of radiation, energy interactions with the earth surface features, concept of spectral signatures.                                       |
| Unit III       | <b>Image Interpretation:</b><br>Characteristics of remote sensing data; preprocessing; Enhancements, Classification, data acquisition and interpretation,                                                                         |
| <b>Block 2</b> | <b>Aerial photographs and Sensor:</b>                                                                                                                                                                                             |
| Unit IV        | <b>Data Processing:</b><br>Image acquisition and processing, image classification, elements of photo and imagery pattern and interpretation-drainage, erosion, details, gray tones, and applications of digital image processing. |
| Unit VIII      | <b>Aerial Photographs</b><br>Basic concepts– types, scale, resolution of aerial photography; properties of aerial photos, applications of aerial photography.                                                                     |
| Unit V         | <b>Sensor:</b><br>Sensor system, types of sensors, imaging and non-imaging sensors, active and passive sensors, resolution of sensors - spectral, spatial, radiometric & temporal, scale, mapping unit.                           |
| <b>Block 3</b> | <b>Platforms, Satellites and Application of Remote Sensing:</b>                                                                                                                                                                   |
| Unit VI        | <b>Platforms</b><br>Types and their characteristics of platforms, ground, airborne and space borne platforms.                                                                                                                     |
| Unit VII       | <b>Satellites and Orbits</b><br>Satellites, types of satellites, satellites and their characteristics, meteorological satellites, types of orbits, orbital characteristics–coverage, passes, pointing accuracy.                   |
| Unit IX        | <b>Application of Remote Sensing:</b><br>Application of remote sensing in atmospheric, hydrosphere, environmental, oceanographic, agriculture and urban planning studies.                                                         |
| <b>Block 4</b> | <b>Global Information System</b>                                                                                                                                                                                                  |
| Unit X         | <b>Basic Concepts:</b><br>Definition of GIS, components of GIS, variables-points, lines, polygon, functionality of GIS, areas of GIS application, advantage and limitation of GIS.                                                |
| Unit XI        | <b>GIS Data:</b><br>Spatial and attribute data, information organization and data structures - raster and vector data structures, data file and database.                                                                         |
| Unit XII       | <b>GIS Software and map scale:</b><br>GIS and remote sensing software, projection systems, categories of maps, map scales.                                                                                                        |

**Suggested Text Book Readings:**

1. M. Anji Reddy, Text Book of Remote Sensing and Geographical Information Systems, Publications/BSP Books-2012.
2. Kali Charan Sahu, Textbook of Remote Sensing and Geographical Information Systems, Atlantic Publishers and Distributors (P) Ltd-2023.
3. K. Subramanya, Engineering Hydrology, McGraw Hill Education, 2017.
4. Joseph, G., 2003. Fundamentals of Remote Sensing, University press.
5. Jensen, J. R. Introductory digital image processing a remote sensing perspective, Prentice Hall series in geographic information science.

**Suggested online links:**

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ol style="list-style-type: none"> <li>1. Introduction to Remote Sensing: <a href="#">Introduction To Remote.pdf</a></li> <li>2. Basic Concepts Of Remote Sensing: <a href="#">Remote Sensing (nptel.ac.in)</a></li> <li>3. Basic Concepts Of Remote Sensing <a href="#">Microsoft PowerPoint - Lecture 4 Remote Sensing Introduction to GIS Atta [Compatibility Mode] (uop.edu.pk)</a></li> <li>4. Global Information System: <a href="#">ACKNOWLEDGEMENT (lsp4you.com)</a></li> <li>5. Introduction to GPS: <a href="#">Data Model in GIS   Data Model in GIS _ e.pathshala   By SudoorSamved RS.GIS   Facebook</a></li> </ol> |
| This course can be opted as an elective by the students of following subjects: NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Suggested equivalent online courses (MOOCs) for credit transfer:</b> complete both course <ol style="list-style-type: none"> <li>1. Basics of Remote Sensing, Geographical Information System (GIS) and Global Navigation Satellite System (GNSS): <a href="#">Basics of Remote Sensing, Geographical Information System (GIS) and Global Navigation Satellite System (GNSS) - Course (swayam2.ac.in)</a></li> <li>2. Remote Sensing Essentials: <a href="#">Free Online Course: Remote Sensing Essentials from Swayam   Class Central</a></li> </ol>                                                                         |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                            |               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Programme: M.Sc.                                                                                                                                                                                                                                                                                                                                                                                                                                          | Year: 2025-26                                                                                                                                                                              | Semester: III |
| Subject: <b>Environmental Science</b>                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                            |               |
| Course Code: <b>PGEVS-113N</b>                                                                                                                                                                                                                                                                                                                                                                                                                            | Course Title: <b>Plant Stress and Physiology</b>                                                                                                                                           |               |
| <b>Course Objectives:</b> <ul style="list-style-type: none"><li>• To discuss about plant physiology</li><li>• To discuss different types plant stress</li><li>• To discuss about plant minerals and plant growth hormones</li><li>• To discuss about nitrogen fixation and carbon assimilation</li></ul>                                                                                                                                                  |                                                                                                                                                                                            |               |
| <b>Course Outcomes:</b> <ul style="list-style-type: none"><li>• CO 1: Able know about plant stress and their physiology</li><li>• CO 2: Learn about water, salinity and metal stress in plant</li><li>• CO 3: Able to know about plant cell and transportation system in plant</li><li>• CO 4: Learn the process of photosynthesis and carbon assimilation</li><li>• CO 5: Also know the role of nitrogen in plant and it assimilation in plant</li></ul> |                                                                                                                                                                                            |               |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Type of Course:</b> Core                                                                                                                                                                |               |
| Max. Marks: 100                                                                                                                                                                                                                                                                                                                                                                                                                                           | Min. Passing Marks: 36                                                                                                                                                                     |               |
| <b>Block 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Drought and Heat Stress</b>                                                                                                                                                             |               |
| Unit I                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Introduction of Plant Stress:</b><br>Stress, types of stress, classification of different kinds of abiotic stresses, interactions between biotic and abiotic stresses, stress proteins. |               |
| Unit II                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Drought and Water Deficit Stress:</b>                                                                                                                                                   |               |

|                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                         | Morphological and physiological responses to drought, drought resistance mechanisms: escape and dehydration postponement, signal perception and signal transduction in drought stress dehydration tolerance, water loss from plants-driving force for transportation, evapotranspiration.                                                          |
| Unit III                                                                                                                                                | <b>Heat Stress:</b><br>Heat wave tolerance mechanism's role of membrane lipids in high temperature tolerance. Chilling and freezing stress, frost and cold injury effects on physiological process, crucial role of membrane lipid, heat shock protein (HSPs).                                                                                     |
| <b>Block 2</b>                                                                                                                                          | <b>Salinity Stress and Stress Protein</b>                                                                                                                                                                                                                                                                                                          |
| Unit IV                                                                                                                                                 | <b>Salinity Stress:</b><br>Alkalinity and salinity, Salinity effects at cellular and whole plant level, effects of salinity on growth, yield and some physiological processes of crop plants, molecular mechanism of salt tolerance, salt stress perception and signal transduction, compatible solutes and osmotic adjustment.                    |
| Unit V                                                                                                                                                  | <b>Metal Stress:</b><br>Aluminum and cadmium toxicity, physiological processes affected by aluminum and cadmium, alleviation of heavy metal stress by various technologies, role of phytochelatin.                                                                                                                                                 |
| Unit VI                                                                                                                                                 | <b>Reactive Oxygen Species (ROS):</b><br>Generation of ROS in plants-Fenton reaction and Haber-Weiss reaction, stress signaling molecules, reactive oxygen species (ROS), role of scavenging systems (SOD catalase etc.).                                                                                                                          |
| <b>Block 3</b>                                                                                                                                          | <b>Plant Growth Regulator and Minerals</b>                                                                                                                                                                                                                                                                                                         |
| Unit VII                                                                                                                                                | <b>Plant Cell and Transportation:</b><br>Plant cell, absorption and transportation of water, properties of solution, permeability, imbibition's, osmosis, ascent of sap.                                                                                                                                                                           |
| Unit VIII                                                                                                                                               | <b>Plant Growth Regulator:</b><br>Phytohormones and its effect on plant growth and development, regulation of plant morphogenetic processes by light, applications of plant growth hormones in agriculture.                                                                                                                                        |
| Unit IX                                                                                                                                                 | <b>Plant Minerals:</b><br>Mineral elements in plants, types of plant nutrients, classification of mineral nutrients, availability of micro and macronutrients, essential and non essential nutrients, deficiency diseases of mineral elements in plants.                                                                                           |
| <b>Block 4</b>                                                                                                                                          | <b>Nitrogen Fixation and Carbon Assimilation</b>                                                                                                                                                                                                                                                                                                   |
| Unit X                                                                                                                                                  | <b>Nitrogen Fixation and Assimilation:</b><br>Biological nitrogen fixation by free living and in symbiotic association, structure and function of enzyme nitrogenase, assimilation of nitrate, assimilation of ammonia into organic compounds.                                                                                                     |
| Unit X                                                                                                                                                  | <b>Photosynthesis:</b> Chloroplast structure, photosynthetic apparatus, pigment structure and function, photochemical reaction, mechanisms of ATP synthesis, electron transport chain.                                                                                                                                                             |
| Unit XII                                                                                                                                                | <b>Carbon Assimilation:</b><br>CO <sub>2</sub> fixation and reduction in Calvin cycle, CO <sub>2</sub> fixation in C <sub>4</sub> plants; CO <sub>2</sub> fixation in CAM plants and its significance, difference among C <sub>3</sub> , C <sub>4</sub> and CAM plants, photorespiration, effect of environmental factors on photosynthetic rates. |
| <b>Suggested Text Book Readings:</b><br>1. A Textbook of Plant Physiology, Biochemistry and Biotechnology, S K Verma, Mohit Verma, S Chand Publication. |                                                                                                                                                                                                                                                                                                                                                    |

2. Fundamentals of Plant Physiology, by V. K. Jain , S Chand Publication.
3. Introduction to Plant Physiology, Norman P. A. Hüner ,William G. Hopkins, Wiley publication, 2008.
4. Physiochemical and Environmental Plant Physiology, Fourth Edition, P. S, Nobel, Academic Press
5. Plant Growth and Development: Hormones and Environment. Srivastava, L. M, Academic Press, USA.

**Suggested online links:**

1. The Stress Concept in Plants: An Introduction: [The Stress Concept in Plants: An Introduction \(usp.br\)](#)
2. Reactive oxygen species in plants: Their generation, signal transduction, and scavenging mechanisms:  
[Reactiveoxygenspeciesinplants\\_theirgenerationalsignaltransductionandscavengingmechanisms.pdf](#)
3. An Introduction to Reactive Oxygen Species: [ROS White Paper 2015.pdf \(biotek.com\)](#)
4. Plant Growth Regulators: [Plant Growth Regulators: Their Use in Crop Production \(iastate.edu\)](#)
5. Nitrogen assimilation: [Slide 1 \(dducollegedu.ac.in\)](#)

This course can be opted as an elective by the students of following subjects: NA

Suggested equivalent online courses (MOOCs) for credit transfer: NA

|                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                              |                                                   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|
| <b>Course prerequisites:</b> Basics in Research                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                              |                                                   |
| <b>Programme:</b> M.Sc./M.A.                                                                                                                                                                                                                                                                             | <b>Year:</b> II                                                                                                                                                                                                                              | <b>Semester:</b> III                              |
| <b>Subject:</b> Statistics                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                              |                                                   |
| <b>Course Code:</b> <i>PGRT-03</i>                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                              | <b>Course Title:</b> <i>Basics Research Tools</i> |
| <b>Course Objectives:</b> The main objective of this course is to develop a research orientation among the scholars and to acquaint them with fundamentals of basic computer tools, research tools, indexing of research paper and scientific report writing.                                            |                                                                                                                                                                                                                                              |                                                   |
| <b>Course Outcomes:</b><br><b>CO1:</b> To know about the research tools and indexing of a research paper.<br><b>CO2:</b> To know about the fundamentals of basic computer tools and how to use it in research.<br><b>CO3:</b> Able to know the writing the research paper and scientific report writing. |                                                                                                                                                                                                                                              |                                                   |
| <b>Credits:</b> 4                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                              | <b>Type of Course:</b> Core                       |
| <b>Max. Marks:</b> 100                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                              | <b>Min. Passing Marks:</b> 36                     |
| <b>Block 1</b>                                                                                                                                                                                                                                                                                           | <b>Introduction</b>                                                                                                                                                                                                                          |                                                   |
| Unit 1                                                                                                                                                                                                                                                                                                   | <b>MEASURES OF CENTRAL TENDENCY MEASURES:</b> Introduction, Definition. Objectives of Average .Characteristics of Good Average . Types of Average. Arithmetic Mean. Weighted Arithmetic Average .Median .Mode .Geometric Mean .Harmonic Mean |                                                   |
| Unit 2                                                                                                                                                                                                                                                                                                   | <b>MEASURES OF DISPERSION:</b> Introduction. Definition .Objectives of Measuring Dispersion. Different Measures of Dispersion. Range .Standard Deviation . <b>Lorenz Curve</b> . Skewness . Kurtosis                                         |                                                   |

|                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Block 2</b> | <b>PROBABILITY</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Unit 3         | <b>PROBABILITY – 1:</b> Introduction . <b>Meaning and Definition of Probability. Probability Defined.</b> Experiment. Sample Space (S). Event. Types of events in probability. Probability Measure. Probability Rules:. <b>Probability Theorems. Addition Theorem. Multiplication Theorem</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Unit 4         | <b>PROBABILITY 2:</b> Conditional Theory. Key Concepts of conditional theory. Applications of conditional theory . Bayes' Theorem. Application of Bayes' Theorem. . Theoretical distribution . Uses of Theoretical Distributions. Types of Theoretical Distributions. Benefits Of Theoretical Distributions. Introduction. Binomial Distribution in Statistics . What Is The Binomial Distribution Formula?. Assumption For Binomial Distribution . Common Applications of Binomial Distribution. Poisson Distribution. Key Characteristics of Poisson distribution. Probability Mass Function (PMF). Applications of Poisson distribution. Assumptions of Poisson distribution. Common Uses of Poisson distribution. How to Solve Problems of Poisson distribution? |
| Unit 5         | <b>PROBABILITY 3:</b> Introduction;. Binomial Distribution in Statistics . What Is The Binomial Distribution Formula?. Assumption For Binomial Distribution . Common Applications of Binomial Distribution. Poisson Distribution, Key Characteristics of Poisson distribution, Probability Mass Function (PMF), Applications of Poisson distribution, Assumptions of Poisson distribution, Common Uses of Poisson distribution, How to Solve Problems of Poisson distribution?, Introduction, Key Characteristics of Normal Distribution, Properties of Normal Distribution, Application of Normal Distribution, Types of Normal Distribution                                                                                                                        |
| <b>Block 3</b> | <b>SAMPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Unit 6         | <b>SAMPLING:</b> Introduction: Meaning of Sampling, Need of Sampling, Advantages of Sampling, Limitations of Sampling                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Unit 7         | <b>SAMPLING METHODS OF DATA COLLECTION:</b> Sampling, Data Collection, <b>Methods For Collecting Statistical Data</b> , Types Of Data, Primary And Secondary Data, <b>Primary Data, Secondary Data</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Unit 8         | <b>SAMPLING DISTRIBUTION:</b> Probability and Non-Probability Sampling, Sampling Techniques, Probability or Random Sampling, Simple Random Sampling, Stratified Sampling , Systematic Sampling , Cluster Sampling, Area Sampling, Probability-proportional-to-size sampling, Double Sampling and Multiphase Sampling, Non-probability or Non Random Sampling, Quota sampling, Convenience or Accidental sampling, Purposive (or judgment) Sampling, Snow-ball Sampling                                                                                                                                                                                                                                                                                               |
| Unit 9         | <b>SOURCES OF DATA COLLECTION:</b> Introduction: Meaning and Importance of Data, Primary Sources of Data, Advantages of Primary Data, Disadvantages of Primary Data, Methods of Collecting Primary Data, Secondary Sources of Data, Features and Uses of Secondary Data, Advantages of Secondary Data, Disadvantages of Secondary Data, Methods of Collecting Secondary Data, Difference between Primary Data and Secondary Data, Questionnaire and Schedule Construction, Basic Rules for Questionnaire Item Construction                                                                                                                                                                                                                                           |
| <b>Block 4</b> | <b>STATISTICAL INVESTIGATION AND ESTIMATION</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Unit 10        | <b>STATISTICAL ESTIMATION:</b> Introduction, Point estimation , Types of point estimators , Properties of point estimator, Point estimation methods , Advantages of Point estimation:, Disadvantages of Point estimation , Errors in Point Estimation, Uses of Point Estimation , Interval estimation Types of Interval estimation, Properties of Interval estimation, Interval estimation methods , Advantages of Interval estimation, Disadvantages of Interval estimation, Errors in Interval estimation, Uses of Interval estimation                                                                                                                                                                                                                             |

|         |                                                                                                                                                                                                                                                                                                                                                                                                                    |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit 11 | <b>SAMPLING TEST:</b> Introductions , Types of Sampling , Sampling Methods, Sampling Test Statistics: Hypothesis Testing:, Common Sampling Tests, Large sample, Benefits of Large sample, Limitation of Large Sample , Test for large sample , Some specific tests for large samples include , Small Sample , Benefits of Small Sample, Limitations of Small Sample, Types of Small Sample , Test For Small Sample |
| Unit 12 | <b>HYPOTHESIS TESTING:</b> Introduction or Conceptual Framework of Hypothesis, Uses of Hypothesis, Scientific Hypothesis, Measures of Hypothesis, Statistical Hypothesis testing, Hypothesis Error                                                                                                                                                                                                                 |
| Unit 13 | <b>NON PARAMETRIC TEST:</b> Non parametric test, Wilcoxon rank-sum test (Mann-Whitney U test), The Wilcoxon signed-rank test, The Kruskal-Wallis H test, Spearman's rank correlation, Chi-square test                                                                                                                                                                                                              |
| Block 5 | <b>Statistical Tools</b>                                                                                                                                                                                                                                                                                                                                                                                           |
| Unit 14 | <b>CORRELATION AND REGRESSION:</b> Introduction, Definitions, Types of Correlation, Methods of Determining Correlation, Calculation of Coefficient of Correlation, Rank Correlation, Regression, Utility of Regression, Methods of Studying Regression, Regression Equation, Comparison of Correlation and Regression                                                                                              |
| Unit 15 | <b>STATISTICAL QUALITY CONTROL (SQC):</b> Introduction, Key components of SQC, Benefits of SQC, Uses of SQC, Limitations of Statistical Quality Control, Functions of Statistical Quality Control                                                                                                                                                                                                                  |
| Unit 16 | <b>CONSTRUCTION OF CONTROL CHARTS:</b> Introduction to Control Charts, Key Components of a Control Chart,How Control Charts Work, Types of Control Charts, Construction of Control Charts, Formula to calculate control chart,Control Chart Constants                                                                                                                                                              |
| Unit 17 | <b>CHI SQUARE TEST:</b> Introduction, Chi-Square as Non-Parametric Test, Test of Goodness of Fit                                                                                                                                                                                                                                                                                                                   |

|                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                           |              |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|--------------|
| Programme: M.Sc.                                                                                                                                                                                                                                                                                                                                                                                                 | Year: 2025-26                                             | Semester: IV |
| Subject: Environmental Science                                                                                                                                                                                                                                                                                                                                                                                   |                                                           |              |
| Course Code: PGEVS-116N                                                                                                                                                                                                                                                                                                                                                                                          | Course Title: Geosciences and Natural Resource Management |              |
| <b>Course Objectives:</b> <ul style="list-style-type: none"><li>• To discuss the geological process and their role in understanding the earth structure.</li><li>• To discuss the geochemical cycle and biogeochemical factor in environmental health</li><li>• To discuss the natural hazardous and disaster management</li><li>• To discuss the natural resource and approach to resource management</li></ul> |                                                           |              |

|                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Outcomes:</b><br>CO 1: Learn about earth surface process and landscape<br>CO 2: Able to know geochemistry of earth system<br>CO 3: Lean about types of disaster and their assessment and vulnerability<br>CO 4: Able to do natural resources management<br>CO 5: learn about ecological, social and economic dimension of natural resources |                                                                                                                                                                                                                                                                                                                                                 |
| Credits: 4                                                                                                                                                                                                                                                                                                                                            | <b>Type of Course:</b> Core                                                                                                                                                                                                                                                                                                                     |
| Max. Marks: 100                                                                                                                                                                                                                                                                                                                                       | Min. Passing Marks: 36                                                                                                                                                                                                                                                                                                                          |
| <b>Block 1</b>                                                                                                                                                                                                                                                                                                                                        | <b>Environmental Geosciences</b>                                                                                                                                                                                                                                                                                                                |
| Unit I                                                                                                                                                                                                                                                                                                                                                | <b>Earth Surface Process and Biosphere:</b><br>Conservation of matter in various geospheres- lithosphere, hydrosphere atmosphere and biosphere, geological processes and their role in understanding Earth structure, Plate Tectonics, General relationship between landscape, biomes and climate                                               |
| Unit II                                                                                                                                                                                                                                                                                                                                               | <b>Environmental Geochemistry:</b><br>Concept of major, trace and REE (Rare Earth Element), classification of trace elements, mobility of trace elements, geochemical cycles, biogeochemical factors in environmental health, possible effects of imbalance of some trace elements.                                                             |
| Unit III                                                                                                                                                                                                                                                                                                                                              | <b>Natural Hazards and Disaster:</b><br>Hazard and disaster, study of floods, landslides, earthquakes, volcanism and avalanche, dimensions of disaster, classification of natural hazards, natural hazards and human intervention, hazard assessment, vulnerability, catastrophic geological hazards.                                           |
| <b>Block 2</b>                                                                                                                                                                                                                                                                                                                                        | <b>Natural Resource-I</b>                                                                                                                                                                                                                                                                                                                       |
| Unit IV                                                                                                                                                                                                                                                                                                                                               | <b>Introduction to Natural Resource:</b><br>Concept of resource, classification of natural resources, factors influencing resource availability, distribution and uses, ecological, social and economic dimension of resource management, interrelationships among different types of natural resources.                                        |
| Unit V                                                                                                                                                                                                                                                                                                                                                | <b>Soil Resources:</b><br>Soil profile, soil characteristic, soil organic matter and humus, soil conservation and erosion, methods of soil conservation, desertification, land as a resource, integrated land use planning, land use classification, land degradation.                                                                          |
| Unit VI                                                                                                                                                                                                                                                                                                                                               | <b>Forest Resources:</b><br>Natural and manmade forest, forest cover, major forest types and their characteristics, deforestation, Afforestation desertification, forest conservation, social forestry, reserved forest, protected forest, national forest policy 1952, forest conservation act, 1980, forest rights act, amendment rules 2012. |
| <b>Block 3</b>                                                                                                                                                                                                                                                                                                                                        | <b>Natural Resource-I I</b>                                                                                                                                                                                                                                                                                                                     |
| Unit VII                                                                                                                                                                                                                                                                                                                                              | <b>Food Security Resources:</b><br>National and international food, changes caused by agriculture and over-grazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, security.                                                                                                                            |
| Unit VIII                                                                                                                                                                                                                                                                                                                                             | <b>Fish and Marine Resources:</b><br>Production, status, dependence on fish resource, unsustainable harvesting, issues and challenges for resource supply, new prospects.                                                                                                                                                                       |
| Unit IX                                                                                                                                                                                                                                                                                                                                               | <b>Energy Resources:</b><br>Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources, use and exploitation of petroleum, coal and natural gas.                                                                                                                                                         |
| <b>Block 4</b>                                                                                                                                                                                                                                                                                                                                        | <b>Natural Resource and Management</b>                                                                                                                                                                                                                                                                                                          |
| Unit X                                                                                                                                                                                                                                                                                                                                                | <b>Mineral Resources:</b><br>Use and exploitation, minerals and its physical properties, classification of                                                                                                                                                                                                                                      |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | mineral, weathering and mineral formation, environmental effects of extracting and using mineral resources, case studies.                                                                                                                                                                               |
| Unit X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Water Resources:</b><br>Groundwater and aquifer, surface water, stream water, watershed, estuaries, flood plain and wetland, integrated water management system, rainwater harvesting, dams-benefits and problem.                                                                                    |
| Unit XII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Approaches in Resource Management:</b><br>Ecological approach, economic approach; ethnological approach, implications of the approaches, integrated resource management strategies. Poverty and implications in resource management in developing countries, resource extraction and control system. |
| <b>Suggested Text Book Readings:</b> <ol style="list-style-type: none"> <li>1. Sustainable Natural Resource Management: For Scientists and Engineers, D. R. Lynch, Publisher: Cambridge University Press.</li> <li>2. Concepts of Environmental Management for Sustainable Development Publisher, M.C. Dash, I K International Publishing House Pvt. Ltd.</li> <li>3. Environmental Geology: An Earth Systems Approach, Dorothy Merits, W.H. Freeman-2014</li> <li>4. Environmental Geography, Savindra Singh, Pravalika Publications-2019</li> <li>5. Natural Resources Conservation &amp; Management, K. K. Singh, M D Publications Pvt. Ltd</li> </ol> <b>Suggested online links:</b> <ol style="list-style-type: none"> <li>1. Earth's structure: <a href="http://deakin.edu.au">untitled (deakin.edu.au)</a></li> <li>2. Surface Processes: <a href="http://eolss.net">Surface Process (eolss.net)</a></li> <li>3. Elements Of Geology: <a href="http://geologic_processes_on_earth.pdf">geologic_processes_on_earth.pdf (nist.gov)</a></li> <li>4. Geologic Processes On Earth: <a href="http://PowerPoint Presentation (nist.gov)">PowerPoint Presentation (nist.gov)</a></li> <li>5. Climate Zones and Biomes: <a href="http://Year 3 Unit 4 Biomes workbook 0.pdf">Year 3 Unit 4 Biomes workbook 0.pdf (arkconway.org)</a></li> <li>6. The Major Biomes: <a href="http://biomesummarylpa_rev (d43fweuh3sg51.cloudfront.net)">biomesummarylpa_rev (d43fweuh3sg51.cloudfront.net)</a></li> <li>7. Natural Resource Management: <a href="http://B (worldbank.org)">B (worldbank.org)</a></li> </ol> Natural Resources: <a href="http://Chapter2.p65 (ugc.ac.in)">Chapter2.p65 (ugc.ac.in)</a> |                                                                                                                                                                                                                                                                                                         |
| This course can be opted as an elective by the students of following subjects: NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                         |
| Suggested equivalent online courses (MOOCs) for credit transfer: <ol style="list-style-type: none"> <li>1. <b>Natural Resources Management:</b> <a href="http://Natural Resources Management - Course (nptel.ac.in)">Natural Resources Management - Course (nptel.ac.in)</a></li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                         |

|                                                                                                                                                                                                                                                                                                                                                    |                                            |              |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|--------------|
| Programme: M.Sc.                                                                                                                                                                                                                                                                                                                                   | Year: 2025-26                              | Semester: IV |
| Subject: Environmental Science                                                                                                                                                                                                                                                                                                                     |                                            |              |
| Course Code: PGEVS-117N                                                                                                                                                                                                                                                                                                                            | Course Title: Atmosphere and Ocean science |              |
| <b>Course Objectives:</b> <ul style="list-style-type: none"><li>• To discuss the origin of the universe</li><li>• To discuss the physical and structural components of atmosphere</li><li>• To discuss the chemistry of aerosol and photochemical</li><li>• To discuss the heat budget and ocean process and their interaction with land</li></ul> |                                            |              |

|                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Outcomes:</b>                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                       |
| CO 1: Able to understanding the origin of universe and their characteristic.         |                                                                                                                                                                                                                                                                                                                                                                                                                       |
| CO 2: Learn chemistry of atmosphere like aerosol and photochemistry                  |                                                                                                                                                                                                                                                                                                                                                                                                                       |
| CO 3: Able discuss heat and water budget of ocean and circulation of Indian ocean    |                                                                                                                                                                                                                                                                                                                                                                                                                       |
| CO 4: Learn the characteristics, role and phenomenon of waves and tides.             |                                                                                                                                                                                                                                                                                                                                                                                                                       |
| CO 5: Also Understand the global effects of ENSO, causes of the irregularity of ENSO |                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Credits: 4                                                                           | <b>Type of Course:</b> Core                                                                                                                                                                                                                                                                                                                                                                                           |
| Max. Marks: 100                                                                      | Min. Passing Marks: 36                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Block 1</b>                                                                       | <b>Atmosphere: Structure and Properties</b>                                                                                                                                                                                                                                                                                                                                                                           |
| Unit I                                                                               | <b>Origin of the Universe:</b><br>Universe and its space and atmosphere, characteristics of deep space environment, atmospheric window and energy flow in atmosphere, heat budget, earth's atmosphere and its significance, measures of water vapor in the atmosphere                                                                                                                                                 |
| Unit II                                                                              | <b>Atmospheric Structure:</b><br>Structure of atmosphere based on vertical temperature profile, gaseous composition and atmosphere based on gaseous composition, temperature stratification and ozone layer.                                                                                                                                                                                                          |
| Unit III                                                                             | <b>Physics of atmosphere</b><br>Vertical thermal structure and composition of the atmosphere, Temperature, variation of temperature, virtual temperature, density, variation of density, pressure and humidity, humidity parameters, thermodynamic properties of dry air - adiabatic temperature change, gas laws and their application to the atmosphere, atmospheric instability and convection-stability criteria. |
| <b>Block 2</b>                                                                       | <b>Atmosphere: Chemistry and Lapse Rate</b>                                                                                                                                                                                                                                                                                                                                                                           |
| Unit IV                                                                              | <b>Atmospheric photochemistry:</b><br>Chemical composition of the earth atmosphere, vertical profiles of major and trace gases, atmospheric photochemistry, reaction of nitrogen, oxygen, ozone, chlorides, Photochemical reactions in atmosphere smog formation and effects on environment.                                                                                                                          |
| Unit V                                                                               | <b>Aerosols Chemistry</b><br>Concept of aerosols, types of aerosol particles, formation and growth of aerosol, lifecycle of aerosol, methods of observations of aerosol, atmospheric aerosol and climate.                                                                                                                                                                                                             |
| Unit VI                                                                              | <b>Atmospheric Stability:</b><br>Concept of lapse rate, atmospheric stability of lapse rate, types of lapse rate, vertical displacement of air, stable atmosphere and unstable atmosphere, turbulent dispersion.                                                                                                                                                                                                      |
| <b>Block 3</b>                                                                       | <b>Fundamentals of Oceanography</b>                                                                                                                                                                                                                                                                                                                                                                                   |
| Unit VII                                                                             | <b>Introduction and water budget of ocean:</b><br>Physical properties of sea water; distribution of temperature, salinity, density and oxygen in space and time; acoustical and optical characteristics of seawater, identification of water masses, water masses diagrams, water masses of the Atlantic, Pacific, and Indian, Ocean.                                                                                 |
| Unit VIII                                                                            | <b>Heat budget of Ocean:</b><br>Insulations, long wave radiation, effect of clouds, sensible and latent heat transfer, Bowen ratio, ocean heat transport, spatio-temporal variability of heat budget terms and net heat balance.                                                                                                                                                                                      |
| Unit IX                                                                              | <b>Ocean Waves and Tides:</b><br>Characteristics, shallow water transformation and breaking, long-shore and cross-shore currents; rip currents, tide generation and propagation, characteristics of tides, tidal current spring and neap tides, diurnal and semi-diurnal tides.                                                                                                                                       |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Block 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Ocean process</b>                                                                                                                                                                                                                                                                                                                   |
| Unit X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Ocean-Atmosphere Interaction:</b><br>Extra-tropical ocean-atmosphere interaction, north Atlantic oscillation, physics of El Nino, La Nina and southern oscillation; global effects of ENSO, causes of the irregularity of ENSO, ENSO teleconnections.                                                                               |
| Unit XI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Ocean-Atmosphere Interface:</b><br>Tropical atmosphere-ocean coupling, effect of wind stress, sea surface temperature and fluxes of heat, moisture and momentum, structure and composition of the coastal atmosphere, dynamics of the exchange of heat, moisture and momentum at the ocean-atmosphere interface.                    |
| Unit XII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Indian Ocean Circulation:</b><br>Ocean surface circulation, equatorial current systems, upwelling and sinking, wind-driven currents in the oceans, northeast and southwest monsoon winds, winter cooling and convection, Indo-Pacific ocean warm pool, circulation in Arabian sea and bay of Bengal, Pacific-Indian ocean exchange. |
| <b>Suggested Text Book Readings:</b> <ol style="list-style-type: none"> <li>1. Dynamics of Ocean and Atmosphere, Gill A., Academic Press</li> <li>2. Atmosphere, Ocean and Climate Dynamics: An Introductory Text, John Marshall, Academic Press.</li> <li>3. An Introduction to Dynamical Meteorology, Holton J R, Academic Press</li> <li>4. Descriptive physical oceanography: an introduction, Lynne D. Talley, Academic Press</li> <li>5. Principles of Ocean Physics, John Ralph Apel, Academic Pres</li> </ol><br><b>Suggested online link:</b> <ol style="list-style-type: none"> <li>1. Origin of the Universe: <a href="#">Chapter4.pdf (uu.edu)</a></li> <li>2. Composition and structure of atmosphere: <a href="#">Microsoft PowerPoint - Chapter.1.composition (uci.edu)</a></li> <li>3. Photochemistry of The Earth's Atmosphere: <a href="#">Microsoft PowerPoint - rodriguez_seminar_6_28.pptx (nasa.gov)</a></li> <li>4. Introduction to Physical Oceanography: <a href="#">por Robert H Stewart.pdf (uv.es)</a></li> <li>5. Basic Concepts in Oceanography: <a href="#">32034841.pdf (iaea.org)</a></li> </ol> |                                                                                                                                                                                                                                                                                                                                        |
| This course can be opted as an elective by the students of following subjects: NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                        |
| Suggested equivalent online courses (MOOCs) for credit transfer: <ol style="list-style-type: none"> <li>1. Introduction to atmospheric Science: NPTEL: Atmospheric Science - Introduction to Atmospheric Science</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                        |

|                                                                                                                                                                                                                                                                                                     |                                                              |              |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|--------------|
| Programme: M.Sc.                                                                                                                                                                                                                                                                                    | Year: 2025-26                                                | Semester: IV |
| Subject: Environmental Science                                                                                                                                                                                                                                                                      |                                                              |              |
| Course Code: PGEVS-118N                                                                                                                                                                                                                                                                             | Course Title: Environmental Impact Assessment and Management |              |
| <b>Course Objectives:</b> <ul style="list-style-type: none"><li>• To discuss the basic Concept of EIA and its methodology</li><li>• To discuss the types, process and significance of environmental audit</li><li>• To about scope, strategy, tools and goals of environmental management</li></ul> |                                                              |              |

|                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>To discuss the strategy of environmental planning and policies</li> </ul>                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Course Outcomes:</b><br>CO 1: Able to know history and scope of environmental impact assessment<br>CO 2: Learn EIA methodology and their significance<br>CO 3: Learn how to EIA filing and take environmental clearance<br>CO 4: able to work on the EIA notification.<br>CO 5: Able to know the concept of environmental planning and sustainable development. |                                                                                                                                                                                                                                                                                                                                                                      |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                         | <b>Type of Course:</b> Core                                                                                                                                                                                                                                                                                                                                          |
| Max. Marks: 100                                                                                                                                                                                                                                                                                                                                                    | Min. Passing Marks: 36                                                                                                                                                                                                                                                                                                                                               |
| <b>Block 1</b>                                                                                                                                                                                                                                                                                                                                                     | <b>EIA and its Methodology</b>                                                                                                                                                                                                                                                                                                                                       |
| Unit I                                                                                                                                                                                                                                                                                                                                                             | <b>Basic Concept of EIA:</b><br>Introduction of EIA, evolution and history of EIA, objective of EIA, EIA-Short-term and Long-term objectives, origin and development of EIA in India, Initial environmental Examination, preparation of Environmental Base map.                                                                                                      |
| Unit II                                                                                                                                                                                                                                                                                                                                                            | <b>Process of EIA:</b><br>Principle of EIA, steps in EIA process-project screening, scoping, baseline data collection, impacts identification, impact prediction and alternative, mitigation measures, EIA Report preparation, Public hearing, decision making, implementation and follow-up.                                                                        |
| Unit III                                                                                                                                                                                                                                                                                                                                                           | <b>Components of EIA:</b><br>Comprehensive and rapid EIA, air environment, environmental monitoring of noise environment, water environment, biological environment, land environment, socio-economic and health environment, risk assessment.                                                                                                                       |
| <b>Block 2</b>                                                                                                                                                                                                                                                                                                                                                     | <b>EIA Methodologies and Notification</b>                                                                                                                                                                                                                                                                                                                            |
| Unit IV                                                                                                                                                                                                                                                                                                                                                            | <b>Environmental Impact Statement (EIS):</b><br>Concept of environmental impact statement, draft statement, impact assessment methodology, Statement documentation, general writing suggestion, and environmental assessment plan (EMP), role and nature of participant involved in EIA.                                                                             |
| Unit V                                                                                                                                                                                                                                                                                                                                                             | <b>E I A Methodologies:</b><br>Introduction, criteria for the selection of EIA methodology, methods of EIA, Ad-hoc methods, matrix methods, network method, environmental media quality index method, overlay method, Cost/benefit analysis – EIS and EMP.                                                                                                           |
| Unit VI                                                                                                                                                                                                                                                                                                                                                            | <b>EIA Notification and Guidelines:</b><br>EIA notification by ministry of environment and forest (Government of India), procedure for environmental clearance, procedure for conducting environmental impact assessment report, evaluation of EIA report, EIA guidelines 2006.                                                                                      |
| <b>Block 3</b>                                                                                                                                                                                                                                                                                                                                                     | <b>Environmental Audit</b>                                                                                                                                                                                                                                                                                                                                           |
| Unit VII                                                                                                                                                                                                                                                                                                                                                           | <b>Introduction to Environmental Audit:</b><br>Concept of environmental auditing, objective of environmental audit, type of environmental audit, principal area of environmental audit, feature of environmental audit, setting up audit program-scope and frequency of audit, environmental audit committee, the audit protocol, advantages of environmental audit. |
| Unit VIII                                                                                                                                                                                                                                                                                                                                                          | <b>Environmental Audit Activity:</b><br>Introduction and scope of environmental auditing, pre-audit activity, activity at site, post audit activity, carrying out the audit-collection information, audit interview, documentation, public disclosure, benefits of environmental audit.                                                                              |
| Unit IX                                                                                                                                                                                                                                                                                                                                                            | <b>Environmental Auditing Report (EAR):</b><br>Preparation of draft report, contents of report, facts and finding of audit, ISO14000 requirements of rule 14 for environmental audit under environmental protection act of 1986.                                                                                                                                     |
| <b>Block-4</b>                                                                                                                                                                                                                                                                                                                                                     | <b>Environmental Management</b>                                                                                                                                                                                                                                                                                                                                      |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Environmental Management:</b><br>Objective and scope of environmental management, strategy of environmental management, goals of environmental management, tools of environmental management, general scheme of environmental management, environmental management system, framework of environmental management system, BS77560 and ISO 14001.                                                                                                  |
| Unit XI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Environmental Planning:</b><br>Evolution and history of environmental planning, environmental concern in urban settlement, development of habitat patterns, environmental approaches to design and planning of rural settlements, use of alternate technology in design of human settlements, conservation aspects of built-up areas, green belt design.                                                                                         |
| Unit XII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Environmental Policy and Sustainable Development:</b><br>Environmental Protection Act 1986, National conservation strategy and policy statement on environment and development 1992, National Environmental Policy 2006, vision statement of environment and health, world commission of environment and development, UN conference on human environment, sustainable development, sustainability and development indicators, carrying capacity. |
| <b>Suggested Text Book Readings:</b> <ol style="list-style-type: none"> <li>1. Environmental Impact Assessment: Theory and Practice, PWathern, Routledge Publishers,</li> <li>2. Environmental Impact Assessment: A Practical Guide, BMarriott, McGraw-Hill Publication,</li> <li>3. Environmental Impact Assessment, Srivastava A.K., et al., APH Publishers</li> <li>4. Environmental Impact Assessment Methodologies, Anjaneyulu Y. et al., CRC Press</li> <li>5. Introduction to EIA, Glasson J., TherivelRiki, Chadwick Andrew, Oxford Brookes University.</li> </ol> <b>Suggested online links:</b> <ol style="list-style-type: none"> <li>1. EIA Methodologies: <a href="http://khitguntur.ac.in">UNIT-2.pdf (khitguntur.ac.in)</a></li> <li>2. Components of EIA: <a href="http://envis.org">envis.org</a> - Components of EIA</li> <li>3. Environmental Auditing: <a href="http://cseindia.org">Microsoft PowerPoint - Environmental Auditing [Compatibility Model] (cseindia.org)</a></li> <li>4. Environmental Management and Planning: <a href="#">Concept types and importance of environm.pdf</a></li> <li>5. Environmental Management and Sustainable Development: <a href="http://ifad.org">E4F82602 (ifad.org)</a></li> </ol> |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| This course can be opted as an elective by the students of following subjects: NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Suggested equivalent online courses (MOOCs) for credit transfer:<br><b>Environmental Impact Assessment:</b> Taught by Prof. Harshit Sosan Lakra, <a href="#">Free Online Course: Environmental Impact Assessment from Swayam   Class Central</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

|                                                                                                                                                                                                                                                                                               |                                                                      |              |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|--------------|
| Programme: M.Sc.                                                                                                                                                                                                                                                                              | Year: 2025-26                                                        | Semester: IV |
| Subject: Environmental Science                                                                                                                                                                                                                                                                |                                                                      |              |
| Course Code: PGEVS-120N                                                                                                                                                                                                                                                                       | Course Title: Environmental Toxicology & Occupational Health Hazards |              |
| <b>Course Objectives:</b> <ul style="list-style-type: none"><li>• To discuss about environmental toxicity and toxicant</li><li>• To discuss about rout of environmental toxicant of human beings</li><li>• To discuss about occupational toxicology and its effects on human health</li></ul> |                                                                      |              |

|                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>To discuss the transformation of toxicant and systematic toxicity</li> </ul>                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                 |
| <b>Course Outcomes:</b><br>CO 1: Able to know the toxicity of environment and its effect<br>CO 2: Learn the duration and exposure of toxicant.<br>CO 3: Able to know the distribution, binding and storage, and excretion of toxicant.<br>CO 4: Know the different types of systematic toxicity.<br>CO 5: Also learn the occupational toxicant exposure and limits |                                                                                                                                                                                                                                                 |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                         | <b>Type of Course:</b> Core                                                                                                                                                                                                                     |
| Max. Marks: 100                                                                                                                                                                                                                                                                                                                                                    | Min. Passing Marks: 36                                                                                                                                                                                                                          |
| <b>Block 1</b>                                                                                                                                                                                                                                                                                                                                                     | <b>Toxicity and Toxicants</b>                                                                                                                                                                                                                   |
| Unit I                                                                                                                                                                                                                                                                                                                                                             | <b>Introduction to Toxicology:</b><br>Definition, history and scope of toxicology, toxicant, types of toxicant, toxicity and toxic agent, factor effects toxicants, target and non organ toxicity, dose effects and dose response relationship. |
| Unit II                                                                                                                                                                                                                                                                                                                                                            | <b>Toxicants:</b><br>Classification of toxic agents, natural toxins, animal toxins, plant toxins, food toxins, genetic poisons and chemical toxins.                                                                                             |
| Unit III                                                                                                                                                                                                                                                                                                                                                           | <b>Duration and exposure of toxicant:</b><br>Acute exposure, chronic exposure, types of human exposure- internal exposure, occupational exposure, environmental exposure, accidental poisoning and internal poisoning                           |
| <b>Block 2</b>                                                                                                                                                                                                                                                                                                                                                     | <b>Toxicity and Public Health</b>                                                                                                                                                                                                               |
| Unit IV                                                                                                                                                                                                                                                                                                                                                            | <b>Fate of toxicant in human body:</b><br>Toxicant absorption, distribution, binding and storage, and excretion, active and passive transport of toxicant.                                                                                      |
| Unit V                                                                                                                                                                                                                                                                                                                                                             | <b>Chemical toxicity in human:</b><br>Alcohol toxicity, toxicity of ketones, minerals toxicity-sodium, potassium, iodine, iron, nitrogen, calcium, zinc, copper, selenium and manganese toxicity, toxicity of dioxins.                          |
| Unit VI                                                                                                                                                                                                                                                                                                                                                            | <b>Public Health:</b><br>Toxicologists and public health, laws and regulations governing toxicants, epidemiological approaches to toxicants, Blacklisted toxic chemicals, pesticide, automobile emission.                                       |
| <b>Block 3</b>                                                                                                                                                                                                                                                                                                                                                     | <b>Systematic Toxicity</b>                                                                                                                                                                                                                      |
| Unit VII                                                                                                                                                                                                                                                                                                                                                           | <b>Renal toxicity</b><br>Renal toxicity- Renal structure and functions, susceptibility of kidney to toxic insult, chemically induced renal injury.                                                                                              |
| Unit VIII                                                                                                                                                                                                                                                                                                                                                          | <b>Cutaneous toxicology:</b><br>Dermatological effects of toxic agents, Allergic contact dermatitis, Cutaneous carcinogenesis                                                                                                                   |
| Unit IX                                                                                                                                                                                                                                                                                                                                                            | <b>Pulmonary and Hepatic toxicity:</b> Toxicant causing respiratory dysfunction, mechanism of entry of toxicant into the lungs, Systematic lung toxins, Actions of toxins on the liver, Chronic liver injury.                                   |
|                                                                                                                                                                                                                                                                                                                                                                    | <b>Carcinogenesis and Testing methods</b>                                                                                                                                                                                                       |
| Unit X                                                                                                                                                                                                                                                                                                                                                             | <b>Carcinogenesis and mutagenicity:</b><br>Carcinogens and carcinogenesis, types of carcinogens, mechanism of carcinogenesis, Mutation and mutagenicity, types of mutation, mechanism of mutagenesis                                            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit XI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Transformation of toxicants:</b><br>Bioaccumulation, biomagnifications, biotransformation, types of biotransformation, biotransformation of DDT, toxic material in environment.                                  |
| Unit XI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Occupational toxicology:</b><br>Occupational toxicants, exposure limits, Risks associated with hazardous substances, Risk assessment and management guidelines, Occupational/Industrial hygiene, Hazard control. |
| <b>Suggested Text Book Readings:</b> <ol style="list-style-type: none"> <li>1. Environmental Toxicology, Kees van Gestel, Vrije University, Amsterdam, <u>Environmental Toxicology</u></li> <li>2. Environmental Toxicology, Third Edition, Sigmund F. Zakrzewski, oxford university press</li> <li>3. A Textbook of Modern Toxicology: Ernest Hodgson A John Wiley &amp; Sons, Inc., Publication</li> <li>4. Principles of Environmental Toxicology, I. Shaw, J. Chadwick, CRC Press</li> <li>5. Occupational Toxicology, Chris Winder, Neill H. Stacey, CRC Press</li> </ol><br><b>Suggested online links:</b> <ol style="list-style-type: none"> <li>1. Introduction to Toxicology Introduction to Toxicology: <u><a href="http://europa.eu">Introduction to toxicology (europa.eu)</a></u></li> <li>2. Chemical toxicology: <u><a href="#">chemical toxicology part 2    effects of heavy metals like arsenic   mercury, chromium, cadmium lead - youtube</a></u></li> <li>3. Drug-induced nephrotoxicity: <u><a href="https://www.scielo.br/j/ramb/a/TC7wp7jkjgSjPMZ9ZNnqdMF/?lang=en&amp;format=pdf">https://www.scielo.br/j/ramb/a/TC7wp7jkjgSjPMZ9ZNnqdMF/?lang=en&amp;format=pdf</a></u></li> <li>4. Toxicology in Occupational and Environmental Setting: <u><a href="#">c01 (wiley-vch.de)</a></u></li> </ol> |                                                                                                                                                                                                                     |
| This course can be opted as an elective by the students of following subjects: NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                     |
| Suggested equivalent online courses (MOOCs) for credit transfer: NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                     |

|                                                                                                                                                                                                                              |                                                   |              |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|--------------|
| Programme: M.Sc.                                                                                                                                                                                                             | Year: 2025-26                                     | Semester: IV |
| Subject: <b>Environmental Science</b>                                                                                                                                                                                        |                                                   |              |
| Course Code: <b>PGEVS-121N</b>                                                                                                                                                                                               | Course Title: <b>Biochemistry and Nanobiology</b> |              |
| <b>Course Objectives:</b> <ul style="list-style-type: none"><li>• To discuss the environmental physiology</li><li>• To discuss the chemistry of cell membrane and effects of environmental factor on cell membrane</li></ul> |                                                   |              |

|                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>To discuss the about enzyme and its role in human physiology</li> <li>To discuss the nanotechnology and its application in environment</li> </ul>                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                      |
| <b>Course Outcomes:</b><br>CO 1: Able to understanding the biochemistry of altered membrane permeability.<br>CO 2: Learn the concept of environmental physiology<br>CO 3: Learn the biochemical approaches to the detoxification of xenobiotics<br>CO 4: Learn the role of nanoscience, nanotechnology and nanobiology<br>CO 5: Also know the environmental applications of nonmaterial |                                                                                                                                                                                                                                                                                      |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                                              | <b>Type of Course:</b> Core                                                                                                                                                                                                                                                          |
| Max. Marks: 100                                                                                                                                                                                                                                                                                                                                                                         | Min. Passing Marks: 36                                                                                                                                                                                                                                                               |
| <b>Block 1</b>                                                                                                                                                                                                                                                                                                                                                                          | <b>Environmental physiology:</b>                                                                                                                                                                                                                                                     |
| Unit I                                                                                                                                                                                                                                                                                                                                                                                  | <b>Environmental physiology:</b><br>Environmental physiology with considerations of intermediary metabolism-approaches for studying energy metabolism and body temperature changes; Thermo regulation and adaptation. Oxygen uptake from the environment, respiration and metabolism |
| Unit II                                                                                                                                                                                                                                                                                                                                                                                 | <b>Biochemistry membrane:</b><br>Biochemistry of altered membrane permeability, free radical formation, lipid peroxidation, lysosomal degradation, superoxide dismutase.                                                                                                             |
| Unit III                                                                                                                                                                                                                                                                                                                                                                                | <b>Detoxification of xenobiotics:</b><br>Biochemical approaches to the detoxification of xenobiotics through cellular metabolism, Environmental pollutants and their effects on living system.                                                                                       |
| <b>Block 2</b>                                                                                                                                                                                                                                                                                                                                                                          | <b>Respiration and Oxidative phosphorylation</b>                                                                                                                                                                                                                                     |
| Unit IV                                                                                                                                                                                                                                                                                                                                                                                 | <b>Respiration:</b><br>Types of respiration, Regulation of plant glycolysis, translocation of metabolites across mitochondrial membrane, TCA cycle.                                                                                                                                  |
| Unit V                                                                                                                                                                                                                                                                                                                                                                                  | <b>Oxidative phosphorylation:</b><br>Mitochondria, electron transport chain-its organization and function, regulation of oxidative phosphorylation.                                                                                                                                  |
| Unit VI                                                                                                                                                                                                                                                                                                                                                                                 | <b>Metabolism of carbohydrates:</b><br>Kreb's Cycle, electron transport system in mitochondria, oxidative phosphorylation and mechanism of ATP synthesis.                                                                                                                            |
| <b>Block 3</b>                                                                                                                                                                                                                                                                                                                                                                          | <b>Fundamentals of Enzyme</b>                                                                                                                                                                                                                                                        |
| Unit VII                                                                                                                                                                                                                                                                                                                                                                                | <b>Introduction to Enzyme</b><br>Enzyme and Enzymology, classification of enzyme, formation of enzyme, enzyme reaction, factor effecting on enzyme reaction.                                                                                                                         |
| Unit VIII                                                                                                                                                                                                                                                                                                                                                                               | <b>Enzymes mechanism:</b><br>Types of mechanism enzymes, activation energy and transition state, enzyme catalyzed reactions, factors effecting the enzyme catalyzed reactions                                                                                                        |
| Unit IX                                                                                                                                                                                                                                                                                                                                                                                 | <b>Coenzymes and cofactors:</b> General properties of enzymes, coenzyme and enzyme proteins, coenzymes involved in different metabolic pathways, phosphate and B <sub>12</sub> coenzymes.                                                                                            |
| <b>Block 4</b>                                                                                                                                                                                                                                                                                                                                                                          | <b>Nanobiology</b>                                                                                                                                                                                                                                                                   |
| Unit X                                                                                                                                                                                                                                                                                                                                                                                  | <b>Introduction to nanoscience:</b><br>Definition of nanoscience, nanotechnology and nanobiology, diffusion in membranes and cells, interactions of biological systems with natural and engineered nanomaterials.                                                                    |
| Unit X                                                                                                                                                                                                                                                                                                                                                                                  | <b>Nanodots:</b><br>Biological Applications-Quantum Devices- carbon nanotubes, nanoparticles                                                                                                                                                                                         |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                              |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | in pharmaceutical and medicinal field, biomedical applications of nanoparticles, health risks of nanoparticles                                                                                                                                                               |
| Unit XII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Nanomaterials:</b><br>Environmental applications, Zerovalent iron nanoparticles, titanium dioxide, silver nanoparticles - nanomembrane process; nanosorbants- mesoporous silica ground water remediation; nano technology based drinking water and waste water treatment. |
| <b>Suggested Text Book Readings:</b> <ol style="list-style-type: none"> <li>1. Environmental Physiology of Animals, Pat Willmer, Graham Stone, Ian Johnston, Blackwell Publishing</li> <li>2. Biochemistry, Kevin Ahern, Indira Rajagopal, Oregon State University</li> <li>3. Textbook of Biochemistry, Seema PavgiUpadhye, Dreamtech Press</li> <li>4. Biochemistry, Satyanarayana, Elsevier</li> <li>5. Introduction to Nanotechnology, Charles P Poole Jr., and Frank J. Ownes, John Wiley Sons, Inc., 2003.</li> </ol> <b>Suggested online links:</b> <ol style="list-style-type: none"> <li>1. Environmental Physiology: <a href="#">75907223.pdf (core.ac.uk)</a></li> <li>2. Cell Membrane and Fluid Mosaic Model: Cell Membrane and Fluid Mosaic Model - YouTube</li> <li>3. Biomembranes structure and function: <a href="#">Slide 1 (unizg.hr)</a></li> <li>4. Electron Transport Chain (Oxidative Phosphorylation): <a href="#">Electron Transport Chain (Oxidative Phosphorylation) - YouTube</a></li> <li>5. Introduction to Enzymes: <a href="#">ed8ad70c5da6e71f70db998dcc27987e.pdf (shivajicollege.ac.in)</a></li> <li>6. Introduction to Enzymes: <a href="#">An Introduction to ENZYMES 122019-v6.pdf (worthington-biochem.com)</a></li> <li>7. Nanomaterials: <a href="#">Chemistry Nanomaterials (gcekjr.ac.in)</a></li> </ol> |                                                                                                                                                                                                                                                                              |
| This course can be opted as an elective by the students of following subjects: NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                              |
| Suggested equivalent online courses (MOOCs) for credit transfer: NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                              |

|                                                                                                                                                                                                                                       |                                                   |              |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|--------------|
| Programme: M.Sc.                                                                                                                                                                                                                      | Year: 2025-26                                     | Semester: IV |
| Subject: Environmental Science                                                                                                                                                                                                        |                                                   |              |
| Course Code: PGEVS-122N                                                                                                                                                                                                               | Course Title: Environmental Biotechnology and IPR |              |
| <b>Course Objectives:</b> <ul style="list-style-type: none"><li>• To discuss the biotechnological aspects on bioreactor and biofertilizers</li><li>• To discuss the biotechnological aspects on bioremediation and bio-fuel</li></ul> |                                                   |              |

|                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>To discuss about laboratory and environmental biosafety</li> <li>To discuss the bio-safety and intactual properties right</li> </ul>                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Course Outcomes:</b><br>CO 1: Able to know the scope of environmental biotechnology.<br>CO 2: Learn the role of biotechnology in waste water treatment.<br>CO 3: Able to know the role of biotechnology in bioreactor and biofertilizers<br>CO 4: Learn the concept of bioremediation and phytooremiation.<br>CO 5:Also learn about Intellectual properties, copyrights and trademarks in briefly |                                                                                                                                                                                                                                                                                                                                                                 |
| Credits: 4                                                                                                                                                                                                                                                                                                                                                                                           | <b>Type of Course:</b> Core                                                                                                                                                                                                                                                                                                                                     |
| Max. Marks: 100                                                                                                                                                                                                                                                                                                                                                                                      | Min. Passing Marks: 36                                                                                                                                                                                                                                                                                                                                          |
| <b>Block 1</b>                                                                                                                                                                                                                                                                                                                                                                                       | <b>Biotechnology for Bioreactors and Biofertilizers</b>                                                                                                                                                                                                                                                                                                         |
| Unit I                                                                                                                                                                                                                                                                                                                                                                                               | <b>Environmental Biotechnology:</b><br>Definition, scope and role of biotechnology in environment protection, Current Status of Biotechnology in Environment Protection, Future Biotechnology for air pollution abatement and odor control: Deodorization process - bioscrubbers, biobeds, Biotrickling filters                                                 |
| Unit II                                                                                                                                                                                                                                                                                                                                                                                              | <b>Bioreactors for Waste:</b><br>Water Treatment: biological processes for industrial treatment-aerobic biological treatments, activated sludge process, biological filters, rotating biological contactors (RBC), anaerobic biological treatment: contact digesters, packed column reactors, upflow anaerobic sludge reactor (UASB)                            |
| Unit III                                                                                                                                                                                                                                                                                                                                                                                             | <b>Biofertilizers:</b><br>Definition and types of biofertilizers, use of microbes as biofertilizers and bioinsecticides to improve productivity and crop protection, biopesticides: bacterial (bt pesticides), fungal (trichoderma), role of symbiotic and symbiotic nitrogen fixing bacteria in the enrichment of soil, algal and fungal biofertilizers (vam). |
| <b>Block 2</b>                                                                                                                                                                                                                                                                                                                                                                                       | <b>Biotechnology for Bioremediation and Bio-filter</b>                                                                                                                                                                                                                                                                                                          |
| Unit IV                                                                                                                                                                                                                                                                                                                                                                                              | <b>Bioremediation:</b><br>Definition and types of bioremediation, bioremediation of contaminants, bioremediation strategy GMO for bioremediation, bioaugmentation,bioremediation of soil and water contaminated with oil spills, heavy metals and pesticides by soil microorganisms, advantage of bioremediation.                                               |
| Unit V                                                                                                                                                                                                                                                                                                                                                                                               | <b>Phytoremediation:</b><br>Concept of phytoremediation, types of phytoremediation, hypo and hyper accumulating plants species, biotechnology in cleaning up the environment by plants, phytoremediation of heavy metal contaminated soils.                                                                                                                     |
| Unit VI                                                                                                                                                                                                                                                                                                                                                                                              | <b>Bio-filter:</b><br>Concept of bio-fiter, types of biofilters, biofiltration media, biotransformation and transport process in biofilters, biofilter for pollutants removal, phytofiltration                                                                                                                                                                  |
| <b>Block 3</b>                                                                                                                                                                                                                                                                                                                                                                                       | <b>Biotechnology for Bioprocess technology</b>                                                                                                                                                                                                                                                                                                                  |
| Unit VII                                                                                                                                                                                                                                                                                                                                                                                             | <b>Bioprocess technology:</b><br>Concept of fermentation, types of fermentation, scaling of fermentation process, application of microbes in industrial production of citric acid and alcohol, role of microbes in processing of various food products and food preservation.                                                                                   |
| Unit VIII                                                                                                                                                                                                                                                                                                                                                                                            | <b>Biofuels technology:</b><br>Role of microbes in energy production, biogas production (Methanogenic bacteria), microbial hydrogen production, ethyl alcohol production from sugarcane and single cell protein (SCP).                                                                                                                                          |
| Unit IX                                                                                                                                                                                                                                                                                                                                                                                              | <b>Biosensor technology:</b><br>Concept of biosensor, ion-selective field effective transistor, thermal sensor, enzyme electrode, immobilized cell biosensor, DNA probe.                                                                                                                                                                                        |
| <b>Block 4</b>                                                                                                                                                                                                                                                                                                                                                                                       | <b>Bio-safety and Intactual Properties Right</b>                                                                                                                                                                                                                                                                                                                |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Introduction to Bio-safety:</b><br>Bio-safety and risk assessment issues, regulatory framework, National biosafety policies and law, The Cartagena protocol on biosafety, WTO and other international agreements related to biosafety.                                                                          |
| Unit XI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Laboratory and environmental biosafety:</b><br>General principle of laboratory and environmental biosafety, Healthy aspects; toxicology, allergenicity, antibiotic resistance etc. Impact on environment; gene flow in natural and artificial ecologies; Sources of gene escape, tolerance of target organisms. |
| Unit XII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>IPR:</b><br>Intellectual properties, copyrights, trademarks, trade secret, patents, geographical indications, etc.; Protection of plant variety and farmers right act; Indian patent act and amendments, patent filing; convention on biological diversity                                                      |
| <b>Suggested Text Book Readings:</b> <ol style="list-style-type: none"> <li>1. Environmental Biotechnology, Principles and Applications by Bruce E Rittman and Perry L McCarty, McGrawhill Higher education.</li> <li>2. Environmental Biotechnology: Theory and Application, Gareth M. Evans, Judith C. Furlong, University of Durham, UK and Taus Biotech Ltd</li> <li>3. Bioremediation and Natural Attenuation by Pedro J JAlvarage and Walter A Illman, Wiley Interscience.</li> <li>4. Law and The Human Body; Property Rights, Ownership and Control, Hardcastel Rohan, Hart Publishing</li> <li>5. Pharmaceutical Biotechnology and the Law, Cook M.Trevor, Lexis Nexis</li> </ol> <b>Suggested online links:</b> <ol style="list-style-type: none"> <li>1. The Bioreactor – an Innovative Method of Disposal of Solid Waste: <a href="#">The_Bioreactor_-an_Innovative_Method_of_Disposal_.pdf</a></li> <li>2. Biofertilizers: <a href="#">Lec 18 - Biofertilizers (eagri.org)</a></li> <li>3. Bioremediation: <a href="#">BSc Chemistry (inlibnet.ac.in)</a></li> <li>4. Application of Biosensors in Environmental Monitoring and Recent Advances: <a href="#">1511255447Paper15EMB_Module26_PCBabitaKhosla_etext.pdf (inlibnet.ac.in)</a></li> </ol> |                                                                                                                                                                                                                                                                                                                    |
| This course can be opted as an elective by the students of following subjects: NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                    |
| Suggested equivalent online courses (MOOCs) for credit transfer:NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                    |

### Practical work

|                |                                               |
|----------------|-----------------------------------------------|
| PGEVS-104N(P)  | Practical's based on PGEVS-101N,102N and 103N |
| PGEVS -109N(P) | Practical's based on PGEVS-106N,107N and 108N |
| PGEVS-114N(P)  | Practical's based on PGEVS 111N,112N and 113N |
| PGEVS -119N(P) | Lab work based on PGEVS -116N,117N and 118N   |
| PGEVS -123N(P) | Lab work based on PGEVS -120N,121N and 122N   |

**Note:** *The topic of practical will be selected from relevant theory paper as per suggestion of relevant faculty members of study centre.*

| <b>PGEVS-124N(D)</b><br>Dissertation/Industrial training/Internship with Viva Voce                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Course Objective:<br/>Project and Dissertation</p> <p>In the last semester of Masters the main objective of the exposure of students' dissertation/Industrial training/ Internship is to elevate their understanding into the practical and experimental aspects of some targeted areas of Environmental Science. This course will develop their analytical ability and it will provide them an apt exposure to work in any research group and will motivate them to execute research in the area of their interest in Environmental Science.</p> <p>Course Outcome:</p> <p>CO-1. Students will be able to plan and strategize a scientific problem, and implement it within a reasonable time frame.</p> <p>CO-2. It is expected that after completing this project dissertation, students will learn to work independently and how to keep accurate/readable record of assigned project.</p> <p>CO-3. In addition, students will be able to know environmental data analysis and their interpretation that will be very helpful for government for policy making and ecological balancing.</p> <p>CO-4. Also, students will be able to become as expert in field of GIS and Remote sensing, Environmental Impact Assessment or any other field of environment as per his dissertation work.</p> <p>CO-5. Subsequently, the students should be able to critically examine research articles, and improve their scientific writing/communication skills and power point presentation.</p> <p>For project work and dissertation, the area of the work would be to be decided by the advisor/mentor.</p> <p>On completion of the project work, students have to submit the work in the form of a dissertation followed by oral presentation in the presence of faculty members.</p> |

## APPENDIX-II

**Guidelines for preparing Research Project/Dissertation is available at link:**

[http://14.139.237.190/upload\\_pdf/01\\_02\\_2023\\_Guidelines\\_for\\_Project\\_Lit\\_Survey\\_Dissertation.pdf](http://14.139.237.190/upload_pdf/01_02_2023_Guidelines_for_Project_Lit_Survey_Dissertation.pdf)