BANASTHALI VIDYAPITH

Master of Science (Environmental Science)

Curriculum Structure

First Semester Examination, December-2020

Second Semester Examination, April/May-2021

Third Semester Examination, December-2021

Fourth Semester Examination, April/May-2022

BANASTHALI VIDYAPITH
P.O. BANASTHALI VIDYAPITH
(Rajasthan)-304022

July, 2020

94

No. F. 9-6/81-U.3

Government of India
Ministry of Education and Culture
(Department of Education)

New Delhi, the 25th October, 1983

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

In exercise of the powers conferred by Section 3 of the University Grants Commission Act, 1956 (3 of 1956) the Central Government, on the advice of the Commission, hereby declare that Banasthali Vidyapith, P. O. Banasthali Vidyapith, (Rajasthan) shall be deemed to be a University for the purpose of the aforesaid Act.

Sd/-
(M. R. Kolhatkar)
Joint Secretary of the Government of India

N O T I C E

Changes in Bye-laws/Syllabi and Books may from time to time be made by amendment or remaking, and a Candidate shall, except in so far as the Vidyapith determines otherwise, comply with any change that applies to years she has not completed at the time of change.

Programme Educational Objectives

Banasthali Vidyapith is an epitome of tradition and modernity. Vidyapith aims to preserve and inculcate the essential values and ideals of Indian culture. It believes in simple living and high thinking. Our educational ideology is based on the concept of fivefold education focusing on physical, practical, aesthetic, moral and intellectual aspects in order to develop a balanced personality.

The M.Sc. in Environmental Science is an interdisciplinary programme which emphasizes the current issues of environment and serious environmental challenges of local, regional and international level that the world confronts. Students will be able to comprehend the interaction between man and its environment along with effect of human activities on the environment and its functions through a series of academic courses and co-curricular activities. Additionally, students will acquire critical thinking and problem solving skills in order to enrich the quality of the environment.

This programme values an integrated approach on learning, conservation, resource management together with inculcation of solution centric approach in resolving the environmental problems to achieve sustainable development. The programme also envisions developing practical leaders having academic excellence and passion to work for the betterment of the environment and create a better dwelling place built on the principles of environmental justice and sustainability.

The main objectives of the M.Sc. Environmental Science programme are:

- To prepare competent environmental professionals in India and across the globe.
- To prepare individuals who are environmentally conscious, empathetic and aware.
- To cultivate an interconnected and interdisciplinary approach towards environmental studies to appreciate the interconnected nature of the world and surroundings in which they live.

- To provide environmental education in a stimulating environment integrated with nationally and internationally recognized research to develop solutions for common environmental issues.
- To prepare students that will communicate excellently about environmental issues in speech and writing.
- To instruct digital literacy to support their professional growth.
- To develop ethical reasoning, diverse viewpoints and decision-making aptitude in students so they can confront environmental issues while considering the perspectives of a variety of stakeholders and systems.
- To foster a spirit in students which lets them to work towards attaining goals and cultivate entrepreneurial capacities.

Programme Outcomes

PO1: **Environmental Knowledge:** Describe the diverse concepts and methods of environmental sciences and their application in various aspects of environmental issues.

PO2: **Planning abilities:** Demonstrate effective planning to deal with different problems associated with environmental issues such as solid waste management, Energy auditing and Impact assessment of various developmental activities.

PO3: **Problem analysis:** Formulate mitigation measures for various environmental issues such as waste management and pollution, food and agriculture, energy, climate change, population, resource management and loss of biodiversity.

PO4: **Design/development of solution for problems:** The research skills strengthen them to formulate hypothesis, identification of environmental problems and develop solution for the betterment of the environment.

PO5: **Modern tool usage:** Apply various tools commonly used in field research, particularly in the study of air water and soil quality along with spatial analysis software and tools such as GIS and GPS technology.

PO6: **Leadership skills:** Use their knowledge of EIA and Environmental laws to critically think about their roles and identities as citizens, consumers and environmental actors in an interconnected world.

PO7: **Professional Identity:** Demonstrate the ability to interpret the consequences of developing projects and consult various environmental agencies to a focused solution.

PO8: **Environmental Ethics:** Appreciate the ethical, cross-cultural, and historical context of environmental issues and the links between human and natural systems.

PO9: **Communication:** Demonstrate proficiency in quantitative methods, qualitative analysis, critical thinking, along with written and oral communication needed to conduct high-level work as interdisciplinary scholars.

PO10: **The Environment and society:** Describe various problems associated with sustainable development of project and its impact on society.

PO11: **Environment and sustainability:** Formulate an action plan for sustainable alternatives that integrate science, humanist, and social perspectives.

PO12: **Life- long learning:** Prepare them for meaningful careers and higher education in fields related to environmental science and beyond.

Curriculum Structure
Master of Science (Environmental Science)

First Year

Semester – I

Course Code	Course Name	L	T	P	C*
ENVS 412	Climate Change and Environment	4	0	0	4
ENVS 402	Ecology and Environment	4	0	0	4
ENVS 405	Environmental Chemistry	4	0	0	4
ENVS 409	Fundamentals of Remote Sensing and GIS	4	0	0	4
ENVS 411	Introduction to Computer for Environmental Science	4	0	0	4
ENVS 403L	Environment Lab - I	0	0	12	6
	Semester Total:	**20**	**0**	**12**	**26**

Semester – II

Course Code	Course Name	L	T	P	C*
ENVS 401	Applications of Remote Sensing for Natural Resource Management	4	0	0	4
ENVS 502	Biodiversity and Conservation	4	0	0	4
ENVS 406	Environmental Legislation	4	0	0	4
ENVS 414	Environmental Statistics and Research Methodology	4	0	0	4
ENVS 415	Environmental Toxicology	4	0	0	4
ENVS 413L	Environment Lab - II	0	0	12	6
	Semester Total:	**20**	**0**	**12**	**26**

Second Year

Semester - III

Course Code	Course Name	L	T	P	C*
ENVS 501	Air Pollution Monitoring, Control Technology and Management	4	0	0	4
ENVS 510	Solid Waste Management	4	0	0	4
ENVS 511	Water Pollution Monitoring, Control Technology and Management	4	0	0	4
ENVS 514L	Environment Lab - III	0	0	12	6
	Discipline Elective	4	0	0	4
	Open Elective	4	0	0	4
	Reading Elective - I	0	0	4	2
	Semester Total:	**20**	**0**	**16**	**28**

Semester - IV

Course Code	Course Name	L	T	P	C*
ENVS 516P	Project	0	0	48	24
	Reading Elective - II	0	0	4	2
	Semester Total:	**0**	**0**	**52**	**26**

List of Discipline Elective

Course Code	Course Name	L	T	P	C*
ENVS 503	Biotechnology Application to Environmental Science	4	0	0	4
ENVS 504	Disaster Management and Mitigation Strategies	4	0	0	4
ENVS 505	Energy Auditing and Conservation	4	0	0	4
ENVS 507	Environmental Health Management	4	0	0	4
ENVS 508	Environmental Impact Assessment and Management	4	0	0	4
ENVS 407	Environmental Physics	4	0	0	4
ENVS 518	Concepts of Atmosphere, Geochemistry and Oceans	4	0	0	4

List of Reading Elective

Course Code	Course Name	L	T	P	C*
ENVS 512R	Agroforestry	0	0	4	2
ENVS 513R	Energy Resources and Conservation	0	0	4	2
ENVS 515R	Man and Environment	0	0	4	2
ENVS 517R	Water and Sustainable Development	0	0	4	2
GEOG 513R	Environmental Challenges and Disaster Management	0	0	4	2
GEOG 514R	India: Socio-Political and Environmental Scenario	0	0	4	2
GEOG 515R	Rajasthan: Challenges and Prospects	0	0	4	2
GEOG 517R	Transforming India	0	0	4	2
GEOL 514R	Geo Tourism	0	0	4	2
GEOL 517R	Indian Mineral Deposits, Economics and Mining Ethics	0	0	4	2

GEOL 518R	Innovation and Entrepreneurship in Earth Sciences	0	0	4	2
GEOL 521R	Natural Hazards and Disasters	0	0	4	2
GEOG 518R	Health, Space and Ecology	0	0	4	2

List of Online Reading Elective
Course Name
Non-Conventional Energy Resources
Mineral Resources: Geology, Exploration, Economics and Environment
Natural Hazards Part-I

*** L - Lecture hrs./week; T - Tutorial hrs./week; P-Project/Practical/Lab/All other non-classroom academic activities, etc. hrs./week; C - Credit Points of the Course**

Student can opt open (Generic) elective from any discipline of the Vidyapith with prior permission of respective heads and time table permitting.

Every Student shall also opt for:

Five Fold Education: Physical Education I, Physical Education II, Five Fold Education: Aesthetic Education I, Aesthetic Education II, Five Fold Education: Practical Education I, Practical Education II one each semester

Project Evaluation Scheme

Duration	Course Code	Course Name	L	T	P	C
1 Semesters (5 months) 1 Jan - 31 May	ENVS 516P	Project	0	0	48	24

Continuous Assessment (40 Marks)

1. Joining report, brief project outlay	- 10 Marks
2. Synopsis	- 10 Marks
3. Mid-term evaluation by Supervisor	- 10 Marks
4. Further evaluation by Supervisor	- 10 Marks
Total	**- 40 Marks**

End Semester Assessment (60 Marks)

1. Project Report	- 20 marks
2. Presentation	- 20 Marks
3. Viva-voce	- 20 Marks
Total	**- 60 Marks**

Five Fold Activities

Aesthetic Education I/II		Physical Education I/II	
BVFF 101	Classical Dance (Bharatnatyam)	BVFF 201	Aerobics
BVFF 102	Classical Dance (Kathak)	BVFF 202	Archery
BVFF 103	Classical Dance (Manipuri)	BVFF 203	Athletics
BVFF 104	Creative Art	BVFF 204	Badminton
BVFF 105	Folk Dance	BVFF 205	Basketball
BVFF 106	Music-Instrumental (Guitar)	BVFF 206	Cricket
BVFF 107	Music-Instrumental (Orchestra)	BVFF 207	Equestrian
BVFF 108	Music-Instrumental (Sarod)	BVFF 208	Flying - Flight Radio Telephone Operator's Licence (Restricted)
BVFF 109	Music-Instrumental (Sitar)	BVFF 209	Flying - Student Pilot's Licence
BVFF 110	Music-Instrumental (Tabla)	BVFF 229	Aeromodelling
BVFF 111	Music-Instrumental (Violin)	BVFF 210	Football
BVFF 112	Music-Vocal	BVFF 211	Gymnastics
BVFF 113	Theatre	BVFF 212	Handball
Practical Education I/II		BVFF 213	Hockey
BVFF 301	Banasthali Sewa Dal	BVFF 214	Judo
BVFF 302	Extension Programs for Women Empowerment	BVFF 215	Kabaddi
BVFF 303	FM Radio	BVFF 216	Karate - Do
BVFF 304	Informal Education	BVFF 217	Kho-Kho
BVFF 305	National Service Scheme	BVFF 218	Net Ball
BVFF 306	National Cadet Corps	BVFF 219	Rope Mallakhamb
		BVFF 220	Shooting
		BVFF 221	Soft Ball
		BVFF 222	Swimming
		BVFF 223	Table Tennis
		BVFF 224	Tennis
		BVFF 225	Throwball
		BVFF 226	Volleyball
		BVFF 227	Weight Training
		BVFF 228	Yoga

Every Student shall also opt for:
Five Fold Education: Physical Education I, Physical Education II,
Five Fold Education: Aesthetic Education I, Aesthetic Education II,
Five Fold Education: Practical Education I, Practical Education II
one each semester

Evaluation Scheme and Grading System

Continuous Assessment (CA) (Max. Marks)					End-Semester Assessment (ESA) (Max. Marks)	Grand Total (Max. Marks)
Assignment		Periodical Test		Total (CA)		
I	II	I	II			
10	10	10	10	40	60	100

In all theory, laboratory and other non classroom activities (project, dissertation, seminar, etc.), the Continuous and End-semester assessment will be of 40 and 60 marks respectively. However, for Reading Elective, only End semester exam of 100 marks will be held. Wherever desired, the detailed breakup of continuous assessment marks (40), for project, practical, dissertation, seminar, etc shall be announced by respective departments in respective student handouts.

Based on the cumulative performance in the continuous and end-semester assessments, the grade obtained by the student in each course shall be awarded. The classification of grades is as under:

Letter Grade	Grade Point	Narration
O	10	Outstanding
A+	9	Excellent
A	8	Very Good
B+	7	Good
B	6	Above Average
C+	5	Average
C	4	Below Average
D	3	Marginal
E	2	Exposed
NC	0	Not Cleared

Based on the obtained grades, the Semester Grade Point Average shall be computed as under:

$$SGPA = \frac{CC_1 * GP_1 + CC_2 * GP_2 + CC_3 * GP_3 + ---- + CC_n * GP_n}{CC_1 + CC_2 + CC_3 + ---- + CC_n} = \frac{\sum_{i=1}^{n} CC_i * GP_i}{\sum_{i=1}^{n} CC_i}$$

Where n is the number of courses (with letter grading) registered in the semester, CC_i are the course credits attached to the i^{th} course with letter

grading and GP_i is the letter grade point obtained in the i^{th} course. The courses which are given Non-Letter Grades are not considered in the calculation of SGPA.

The Cumulative Grade Point Average (CGPA) at the end of each semester shall be computed as under:

$$CGPA = \frac{CC_1 * GP_1 + CC_2 * GP_2 + CC_3 * GP_3 + ----- + CC_n * GP_n}{CC_1 + CC_2 + CC_3 + ----- + CC_n} = \frac{\sum_{i=1}^{n} CC_i * GP_i}{\sum_{i=1}^{n} CC_i}$$

Where n is the number of all the courses (with letter grading) that a student has taken up to the previous semester.

Student shall be required to maintain a minimum of 4.00 CGPA at the end of each semester. If a student's CGPA remains below 4.00 in two consecutive semesters, then the student will be placed under probation and the case will be referred to Academic Performance Review Committee (APRC) which will decide the course load of the student for successive semester till the student comes out of the probationary clause.

To clear a course of a degree program, a student should obtain letter grade C and above. However, D/E grade in two/one of the courses throughout the UG/PG degree program respectively shall be deemed to have cleared the respective course(s). The excess of two/one D/E course(s) in UG/PG degree program shall become the backlog course(s) and the student will be required to repeat and clear them in successive semester(s) by obtaining grade C or above.

After successfully clearing all the courses of the degree program, the student shall be awarded division as per following table.

Division	CGPA
Distinction	7.50 and above
First Division	6.00 to 7.49
Second Division	5.00 to 5.99
Pass	4.00 to 4.99

CGPA to % Conversion Formula: % of Marks Obtained = CGPA * 10

First Semester

ENVS 412 Climate change and Environment

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

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

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

Course Content:

Section A

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

Section B

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

Section C

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

Recommended Books:

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

Suggested e-learning materials:

1. Climate Change
   https://swayam.gov.in/courses/5257-climate-change
   https://nptel.ac.in/courses/119106008/40

ENVS 402 Ecology and Environment

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

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

- Describe the interaction of organisms with their environment.
- Identify the various threats to biodiversity.

- Explain the concept of biomes.
- Describe the various biogeochemical cycles.

Course Content:

Section A

Introduction to Environment:

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

Section B

Concept of Ecology, Ecosystem and Biomes:

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

Section C

Environmental Pollution and its Effect

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

Recommended Books:

1. Atkinson, Raw, M. (2007). *Biogeography*. Philip Allan Updates.
2. Gautam, A. (2007). *Environmental Geography*. Allahabad, India: Sharda Pustak Bhawan.
3. Huggett, R. J. (1998). *Fundamental of Biogeography*. London, UK:Routledge.
4. Kayastha, S.L., & Kumra, V.K. (1986). *Environmental Studies.* Varanasi, India: Tara Book Agency.

5. Mathur, H.S. (1998). *Essentials of Biogeography*. Jaipur, India: Pointer.

6. Mehtani, S., &Sinha, A. (2010). *Biogeography*. Commonwealth.

7. Odum, E. P. (1975). *Ecology*. Lanham, MD:Rowman and Littlefield.

8. Odum, E.P. (1968).*Fundamentals of Ecology*. London, UK:W.B. Sanders Company

9. Saxena, H. M. (1999). *Environmental Geography*. Jaipur, India:Rawat.

10. Saxena, H. M. (2000). *Environmental Management*. Jaipur, India:Rawat.

Suggested e-learning materials:

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

ENVS 405 Environmental Chemistry

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

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

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

Course Content:

Section A

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

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

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

Section B

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

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

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

Aflatoxin occurrence, chemical composition and properties metabolism.

Section C

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

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

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

Recommended Books:

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

Suggested e-learning materials:

1. Environmental Chemistry and Analysis
   https://nptel.ac.in/courses/122106030/
2. Environmental Chemistry
   https://swayam.gov.in/course/251-environmental-chemistry

ENVS 409 Fundamentals of Remote Sensing and GIS

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

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

- Explain about Remote Sensing, Geographical Information System and Global Positioning System.
- Outline and interpret the elements of aerial photographs.

- Describe principles and applications of thermal and microwave remote sensing.
- Differentiate GIS and science of map making, non spatial versus spatial data

Course Content:

Section A

Aerial Photograph

Aerial Photographs: Definition, Basic Terms and Scale. Classification of aerial photographs. Overlapping in aerial photographs and aerial photo mosaics. Elements of aerial photo interpretation

Section B

Remote Sensing

Remote sensing: Definition, Process and Stages. Remote sensing platforms. Electromagnetic Radiation (EMR) - Properties, Interaction of EMR with the earth's surface and atmosphere. Basic Principles and Applications of Thermal and Microwave Remote Sensing

Section C

GIS and GPS

GIS: Concept, Components and Application of GIS. Data Base Management System (DBMS) in GIS. Spatial analysis in GIS. Basic Principles, Segments and Application of GPS

Recommended Books:

1. Abbasi, S. A. (2005). *Application of G I S & Remote Sensing in Environment Managements*. New Delhi, India:Discovery.
2. Avery, T. E., & Berlin, G. L. (1985). *Interpretation of Aerial photographs* (4th ed.). Minneapolis, Minnesota: Burgess.
3. Bhatta, B. (2011). *Remote Sensing and GIS* (2nd ed). New Delhi, India: Oxford University Press.

4. Burrough, P.A., & Rachael A. M. (2015). *Principles of Geographic Information Systems* (3rd ed.).Oxford, UK: Oxford University Press.

5. Ciciarelli, J. A. (1991). *A Practical Guide to Aerial Photography with an Introduction to Surveying.*US: Springer.

6. Curran, P. J. (1985). *Principles of Remote Sensing*. London, UK:Longman.

7. Fazal, S. (2008). *GIS Basics.*New Delhi, India:New Age International.

8. Ganesh, A., & Narayanakumat, R. (2006). *GPS Principles and Applications*. Satish Serial.

9. George, J. (2008). *Fundamentals of Remote Sensing*. Hyderabad, India: Universities Press.

10. Heywood, I., Cornelius, S., & Carver, S. (2000). *Introduction to GIS*. New York, NY: Addison Wesley Longman.

11. Lillesand, T.M., Kiefer, &R.W., Chipman, J.W. (2011). *Remote Sensing and Image interpretation*. Hoboken, NJ: Wiley and Sons.

12. Lo, C.P., & Yeung, A.K.W. (2004). *Concepts and Techniques of GIS*. New Delhi, India: Prentice-Hall of India.

13. Paine, D. P., & Kiser, J. D. (2012). *Aerial Photograph and Image interpretation*. New Jersey, NJ: John Wiley and Sons.

14. Palet, A.N. (1992). *Remote Sensing-Principles & Application*. Jodhpur, India: Scientific.

Suggested e-learning materials:

1. Introduction to Remote Sensing

   https://swayam.gov.in/course/3612-introduction-to-remote-sensing

2. Introduction to Geographic Information Systems

   https:// onlinecourses. nptel.ac.in/noc16_ce12/preview]

ENVS 411 Introduction to Computer for Environmental Science

Max. Marks : 100	L	T	P	C
(CA: 40 + ESA: 60)	4	0	0	4

Learning Outcomes:

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

- Describe the elements of a computer system and functions of its components
- Use various computer operating systems.
- Create worksheets, charts, documents, inserting tables and pictures and presentation package.
- Use photographs and document editing software.

Course Content:

Section A

Introduction to Computers

Elements of a Computer System, Block diagram of Computer System and functions of its components. Evolution of computers and classification, concept of hardware and software. Introduction to Operating Systems (DOS, Windows and UNIX).

Section B

PC Software

Word Processing: Creating and Saving documents, formatting, Inserting Tables and Pictures and Mail Merge. Spread sheet: Creating worksheet, Use of functions and Creating Charts. Introduction to Presentation Packages, Graphics and Animation packages.

Introduction to Computing

Programming languages, system and application software, compiler and interpreters. Concept of a program, program design & development, algorithms and flowchart development.

Section C

Internet & Web

Introduction to popular packages on concept of computer communication,

computer network (LAN, WAN, MAN),

Internet, Internet Services-www, email etc.

Introduction to Computer Applications in Environmental Science

Data Base Management Systems,

Statistical Packages,

Expert Systems,

Multilingual Applications.

Recommended Books:

1. Sinha, P.K. (2017). *Computer Fundamentals.* New Delhi, India: BPB.
2. Taxali, R.K. (2000). *PC Software for window - made simple*. New Delhi, India: Tata Mcgraw Hill.

Suggested e-learning materials:

1. Computer Fundamentals
   https://swayam.gov.in/course/4067-computer-fundamentals
2. Introduction to System: Software
   https://nptel.ac.in/courses /106106092/2

ENVS 403L Environment Lab – I

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**12**	**6**

Learning Outcomes:

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

- Conduct soil sample analysis.
- Conduct water sample analysis.
- Use MS office Package, CorelDraw, Internet services.
- Create and interpret geospatial data.

Course Content:

1. Working with Windows.
2. Working with MS office Package (MS-Word, Excel, Power Point).
3. Working with CorelDraw
4. Using Internet services
5. Using subject specific application packages.
6. Determination of conductivity of water/soil samples.
7. Determination of pH for water/soil samples.
8. Determination of TSS and TDS in water samples.
9. Determination of turbidity in water/soil samples.
10. Determination of BOD in water samples.
11. Determination of Dissolved Oxygen (DO) in water samples.
12. Determination of Sodium, (Na) in water samples.
13. Determination of Potassium, (K) in water samples.
14. Determination of Acidity in water samples
15. Determination of Total Hardness in water samples.
16. Determination of Magnesium Hardness in water samples.
17. Determination of Total Metals (Cr, Fe and Cd) in water samples.
18. Determination of Grain size of soil samples.
19. Determination of leaf area.
20. Introduction to Satellite Images, TCC, FCC
21. Visual Interpretation
22. Stereoscopic Vision
23. Object Identification with Aerial Photograph
24. Introduction to GIS Software
25. Georeferencing

26. Creation of spatial data
27. Joining Non spatial with spatial data
28. Buffering
29. Map layout

Recommended Books:

1. Narasalah, G. L. (2012).*Environmental Science : A Practical Manual*. Delhi, India. : B.S.
2. Maiti, S.K. (2011). *Handbook of Methods in Environmental Studies. Vol. 2: Soil and Air Analysis.* Jaipur, India: Oxford Book Company.
3. Rajaraman, V., &Adabala, N. (2014) *Fundamentals of Computers* (6thed.). New Delhi, India: Prentice Hall.

Suggested e-learning materials:

1. Water Quality Monitoring

   https://nptel.ac.in/courses/103107084/4

2. Particle Size Distribution

   https://nptel.ac.in/courses/105103097/10

Second Semester

ENVS 401 Applications of Remote Sensing for Natural Resource Management

Max. Marks : 100	L	T	P	C
(CA: 40 + ESA: 60)	4	0	0	4

Learning Outcomes:

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

- Use geographical and spatial databases pertaining to land use land cover.
- Perform interactive geospatial analysis, display and interpret results.
- Assess the biophysical and social applications of remote sensing.
- Develop skills to access and plot geospatial data for natural resource management.

Course Content:

Section A

Introduction

Emergence of Remote Sensing technology in application areas, Understanding potentials of Remote Sensing in allied sectors, Indian satellite missions with focused applications, Recent trends in Remote Sensing applications.

Section B

Application in Land and Water Resource

Remote sensing in mapping Land use / land cover classification and monitoring, Crop forecasting, Forest resources management, soil taxonomy and degradation, geomorphology and surface mining on land resources, groundwater modelling, Water quality Monitoring, Reservoir sedimentation, Snow covers mapping and modelling approaches

Section C

Application in Climate change and Disaster Management

Concept of climate and weather, Climatic classification, paleo-climate, Adaptation and vulnerability. Mapping of landslide, Floods, Cyclones, Forest fire and Drought.

Application in Environmental Management

Selection of disposal sites for industrial and municipal wastes, Solid waste management, Environmental Impact Assessment (EIA)

Recommended Books:

1. Jenson, J.R. (2007). *Remote Sensing of the Environment-An Earth Resource Perspective*(2nd ed.). New Jersey, NJ: Prentice Hall.
2. Joshi, P.K., & Singh, T.P. (2011). *Geoinformatics for Climate Change Studies*. New Delhi, India: TERI Press.
3. Joshi, P.K., Pani, S., Mohapartra, N., & Singh, T.P. (2010). *Geoinformatics for Natural Resource Management*. Punjab, India: Nova Science.
4. Kumar, P., Rani, M., & Pandey, P. (2012). *Conservation areas to beat the heat*. Saarbrücken, Germany: LAP LAMBERT Academic.
5. Lillesand, T., Keifer, R.W., & Chipman, J. (2015). *Remote Sensing and Image Interpretation*(7th ed.).Hoboken, NJ: John Willey and Sons.
6. Schultz, G.A. & Engman, E.T. (2000). *Remote Sensing in Hydrology and Water Management*. Berlin, Germany:Springer-Verlag.

Suggested e-learning materials:

1. Introduction to Remote Sensing
   https://nptel.ac.in/courses/121107009/
2. Remote Sensing Applications
   https://nptel.ac.in/courses/105108077/

ENVS 502 Biodiversity and Conservation

Max. Marks : 100	L	T	P	C
(CA: 40 + ESA: 60)	4	0	0	4

Learning Outcomes:

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

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

Course Content:

Section A

Introduction to biodiversity concepts, significance, magnitude and distribution.

Biodiversity trends, diversity gradients and related hypotheses methods for monitoring biodiversity trends.

Threats to biodiversity, major causes, extinction's, vulnerability of species to extinction, IUCN threat categories, Red data book.

Section B

Principles of biodiversity conservation Ex situ and In situ methods of conservation, Genetical and evolutionary principles in conservation. Conservation of biological diversity and its significance- source of food, medicine, raw material, aesthetic, cultural and ecosystem services.

Concepts, distribution and importance of Hot spots.

Strategies for sustainable exploitation of biodiversity.

Section C

Conservation – efforts in India, Endangered flora & fauna of India. ethnobotany in India & selected medicinal plants.

Wildlife conservation in India- Project Tiger, Project crocodile, silent valley controversy. Conservation of Himalayan, Gangetic ecosystems.

Recommended Books:

1. Kumar, U. & Asija, M.J. (2007). *Biodiversity – Principles and conservation* (2nd ed.). Jodhpur, India: Agrobios.
2. Mishra, R. (1968). *Ecology Workbook* (2nd ed.). Calcutta, India: Oxford and IBH.
3. Odum, E.P. (1983). *Basic Ecology* (2nd ed.). Philadelphia,PA: Holt-Saunders International.
4. Odum, E.P. (2004). *Fundamentals of Ecology*. Dehradun, India: Natraj.
5. Singh, M.P., Singh, J.K., Mohanka, R., & Sah, R.B. (2007). *Forest environment and biodiversity (*2nd ed.*)*. New Delhi, India: Daya.
6. Sinha, B.N. (1990). *Ecosystem Degradation in India*. New Delhi, India: Ashish.
7. Tewari, D.N. (1994) *Biodiversity and forest genetic resources*. Dehradun, India: International Book.

Suggested e-learning materials:

1. Aquatic Biodiversity and Environmental Pollution https://nptel.ac.in/courses/120108002/16
2. Wildlife Conservation https://nptel.ac.in/noc/individual_course.php?id=noc18-bt26

ENVS 406 Environmental Legislation

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

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

- Explain fundamental concepts in environmental law and policy.
- Describe the main Environmental Law and Policy regime of the country.
- Outline various international environmental laws in incorporated into environmental policies of national and state governments.

- Examine and analyse legal approaches to pollution control, environmental planning and natural resource management.
- Examine implementation issues associated with environmental regulation and environmental regimes

Course Content:

Section A

Fundamental Principles of Domestic and International Environmental Law

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

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

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

Section B

Domestic Laws on Environment

The Environmental Protection Act 1986, Definition of pollution and pollutant

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

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

National Green Tribunal Act 2010

Section C

Environment Related Other Laws and Policies

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

Recommended Books:

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

Suggested e-learning materials:

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

ENVS 414 Environmental Statistics and Research Methodology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

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

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

Course Content:

Section A

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

Section B

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

Section C

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

Recommended Books:

1. Basotia, G.R. & Sharma, K.K. (1999). *Research Methodology*. Jaipur, India: Mangal Deep.
2. Chaudhary, C.H. (2009). *Research Methodology*. Rajasthan, India: RBSA.
3. Daniel, W. (1987). *Biostatistics: A Foundation for Analysis in the Health Sciences* (4th ed.). New York, NY: John Wiley & Sons Inc.
4. Elhance, D.N., Elhance, V., & Aggarwal, B.M. (2014). *Fundamentals of Statistic*s. New Delhi, India: KitabMahal.

5. Gupta, S.P. (2014). *Statistical Methods* (43rd ed.). New Delhi, India:S. Chand.
6. Khan, I.A., & Khanum, A. (2009). *Fundamentals of Biostatistics*. Hyderabad, India: Ukaaz.
7. Zerold, J. (2008). *Biostatistical Analysis* (3rd ed.). Noida, India: Dorling Kindersley.

Suggested e-learning materials:

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

ENVS 415 Environmental Toxicology

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

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

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

Course Content:

Section A

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

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

Eco-system influence on the fate and transport of toxicants

Abiotic Stress response in living systems.

Section B

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

Global dispersion of toxic substance

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

Section C

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

Recommended Books:

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

4. Gaur, R.K., & Sharma, P. (2013). *Molecular Approaches in Plant Abiotic Stress*. Florida, FL: CRC Press.

5. Gaur, R.K., & Sharma, P. (2014). *Approaches to Plant Stress and their Management*. New Delhi, India: Springer.

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

Suggested e-learning materials:

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

ENVS 413L Environment Lab-II

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**12**	**6**

Learning Outcomes:

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

- Perform water quality analysis.
- Perform biochemical analysis of plant samples.
- Access and plot geospatial data for environmental modeling.
- Demonstrate applications of remote sensing in natural resource management.

Course content:

1. Estimation of Chloride content.
2. Estimation of Alkalinity.
3. Estimation of organic carbon in soil sample.
4. Estimation of Fluoride.
5. Estimation of MDA in plant sample.

6. Estimation of Chlorophyll a in plant samples
7. Estimation of Chlorophyll b in plant samples
8. Estimation of Carotenoids in plant sample
9. To study plant population density by quadrate method
10. To study plant frequency by quadrate method
11. Estimation of sodium in soil samples/ sludge sample
12. Estimation of Potassium in soil samples
13. Estimation of Cr and Pb in soil samples/ sludge sample
14. Crop area estimation using remote sensing
15. Forest cover and density mapping
16. Water quality modeling using remote sensing and GIS
17. Flood hazard analysis using multi- temporal imagery
18. Site suitability for solid waste management
19. Effect of toxicants on insects.
20. Experiment based on food preferences in insects.

Recommended Books:

1. Avery, T.E. & Berlin, G.L. (1985). *Interpretation of Aerial photographs* (4th ed.). Minneapolis: Burgess.
2. Burrough, P.A. & McDonnell, R.A. (1998). *Principles of Geographic Information Systems (Spatial Information Systems)* (2nd ed.). Oxford, UK: Oxford University Press.
3. Heywood, I., Cornelius, S., & Carver, S. (2006). *An introduction to geographical information systems* (3rd ed.). Harlow, England: Pearson Prentice Hall.
4. Lillesand, T.M., Kiefer, R.W. & Chipman J.W. (2011). *Remote Sensing and Image interpretation* (7th ed.).Hoboken, NJ: John Wiley and Sons.

5. Maiti, S.K. (2011). *Handbook of Methods in Environmental Studies. Vol. 1: Water and Wastewater Analysis.* Jaipur, India: Oxford Book Company.

6. Maiti, S.K. (2011). *Handbook of Methods in Environmental Studies. Vol. 2: Soil and Air Analysis.* Jaipur, India: Oxford Book Company.

7. Rajaraman, V., &Adabala, N. (2014) *Fundamentals of Computers* (6^{th}ed.). New Delhi, India: Prentice Hall.

Suggested e-learning materials:

1. Analysis of major constituents in water
   https://nptel.ac.in/courses/122106030/

2. Water Quality Monitoring: Collection of water samples and estimation of physical parameters

   https://nptel.ac.in/courses/103107084/4

Third Semester

ENVS 501 Air Pollution Monitoring, Control Technology and Management

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

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

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

Course Content:

Section A

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

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

Section B

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

Control of specific gaseous pollutants; control of SOx, control of NOx, control of hydrocarbons, and control of carbon mono-oxide

Section C

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

Recommended Books:

1. Buonicore, A., & Theodore L. (1994). *Air Pollution Control Equipment: Selection, Design, Operation and Maintenance*.New York,NY: Springer-Verlag.
2. Buonicore, A., Wayne, T., & Davis (1992). *Air Pollution Engineering Mannual.* New York,NY: Van Nostrand Reinhold.
3. Burke, G., Singh, B. R. & Theodore, L. (2000). *Handbook of Environmental Management and Technology*(2nd ed.). New York, NY: John Wiley & Sons.
4. Cavaseno, V. (1980). *Industrial Air Pollution Engineering*. New York,NY: Mcgraw-Hill.
5. Cheremisinoff, N. P. (2002). *Handbook of Air pollution prevention and control*. Oxford, UK: Butterworth-heinemann Elsevier science.
6. Cheremisinoff, P. N. (1993). *Air Pollution Control and Design for Industry*. New York, NY: Marcel Dekker.
7. De, N. N. (2000). *Air Pollution Control Engineering*(2nd ed.). New York, NY: McGraw-Hill Companies.
8. Heinsohn, R.J. &Kabel, R.L. (1999). *Sources and Control of Air Pollution.*New Jersey,NJ:Prentice.
9. Kovacs, M. 1995. *Pollution Control and Conservation*. Chichester: Ellis Horwood.
10. Kumar, S. & Kumar, R. (2012) *Air Quality – Monitoring and Modeling.* Croatia, Rijeka:In TechJanezaTrdine.

11. Lodge, J. P. (1988). *Methods of Air Sampling and Analysis* (3rd ed.). Boca Raton, FL: Lewis.

12. Metcalf & Eddy, Inc. (1991). *Wastewater Engineering-Treatment, Disposal and Reuse* (3rd ed.). New York, NY: McGraw-Hill.

13. Stern, A. C. (1976). *Air Pollution Measuring, monitoring and surveillance of air pollution* (3rd ed.). Massachusetts, MA: Academic Press.

14. Stern, A. C. (1986). *Air Pollution. Supplement to measuring, monitoring and surveillance and engineering control of air pollution*(3rd ed.).Massachusetts, MA: Academic Press.

15. William, F., & DeRose, (2004) *Principles and Practices of Air Pollution Control*, United States Air Pollution Training Institute (APTI)

Suggested e-learning materials:

1. Environmental air pollution

   https://nptel.ac.in/courses/105102089/air%20pollution%20(Civil)/Module-2/1.htm

2. Stack Monitoring

   https://nptel.ac.in/courses/105102089/8

3. Guidelines for the Measurement of Ambient Air Pollutants http://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMjdfMTQ1ODExMDQyNl9OZXdJdGVtXzE5Nl9OQUFRTVNfVm9sdW1lLUkucGRm

4. Air pollution control technologies http://capacitydevelopment.unido.org/wp-content/uploads/2014/11/25.-Air-Pollution-Control-Technologies-Compendium.pdf

5. Kinetics of Air Pollution and Combustion Process https://nptel.ac.in/courses/105104099/

ENVS 510 Solid Waste Management

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

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

- Describe solid waste generation, composition and characterization.
- Describe waste recycling, 3R technology and fly ash management.
- Outline the landfill design.
- Discuss monitoring and control of radiation pollution.

Course Content:

Section A

Concept of solid waste, Types, composition and classification of solid waste, Effects of solid waste generation on quality of air, water and public health. Need of Solid Waste Management. Principal of Solid Waste Management, Technical approach for solid waste management: collection, transportation, Disposal, Recovery and recycling of organic waste.

3R Principle (Reduce, Reuse and Recycle).

Section B

Solid waste disposal and Management methods – Recycling, Vermi composting and incineration, pyrolysis, biogas generation, solid waste as a source of raw material (light weight bricks from fly ash, composting)

Landfill Planning and designing, Act and rules for Solid waste management.

Case studies on solid wastes (Jaipur city and Vishakhapatnam city)

Section C

Hazardous waste, types of hazardous waste and its classification, Management of hazardous wastes. Biomedical waste and its management

Radioactive waste and pollution – concept, sources, types and possible hazardous of radioactive substances, measurement of radiation intensity.

Monitoring and control of radiation pollution, Effects of radioactive waste.

Recommended Books:

1. Agarwal, S. K. (1997). *Environmental Issues and Threats*. New Delhi, India: A P H.
2. Barrow, C. (1993). *Developing the Environment Problems and Management.* Abingdon UK: Routledge
3. Dhamija, U. (2006). *Sustainable Solid Waste Management-Issues Policies and Structures*. New Delhi, India: Academic Foundation.
4. Hosetti, B. B., & Kumar, D. (1998).*Environmental Impact Assessment and Management*. New Delhi, India: Daya.
5. Manual on Municipal Solid Waste Management (2011).*Prepared by the Expert Committee constituted by the Government of India,* Ministry of Urban Development.
6. Peter, C. (1998). *Handbook of Environmental risk Assessment and Management*. New Jersey, NJ: Blackwell Science.
7. Rasure, K. A. (2007). *Solid Waste Management, Environment and Sustainable Development*. New Delhi, India: Serials.
8. Salomons, W. & Forstner, S. L. (1990). *Environmental Management of Solid waste*.Heidelberg,Berlin: Springer-Verlag.
9. Sundaresan, A. D., & Bhide, B. B. (1987). *Solid Waste Management in Developing countries*. New Delhi, India: INSDOC.

Suggested e-learning materials:

1. Solid waste Management
   https://nptel.ac.in/courses/104103020/42
2. Hazardous waste Management
   https://nptel.ac.in/courses/ 120108005/ module9 /lecture9.pdf
3. Landfill Engineering System
   https://nptel.ac.in/courses/ 105106052/ downloads/Lecture-40.pdf
4. Landfill Type and Liner Systems
   http://ce561.ce.metu.edu.tr /files/2013/11/liner-1.pdf

5. Types of Landfill
   http://www.mfe.govt.nz/waste/guidance-and-technical-information /types- of-landfills
6. Management of High Level Radioactive waste
   http://www. barc.gov.in/pubaware/nw.html
7. Radioactive waste Management
   http://www.barc.gov.in/ pubaware/nw_n3.html

ENVS 511 Water Pollution Monitoring, Control Technology and Management

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

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

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

Course Content:

Section A

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

Section B

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

Section C

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

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

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

Recommended Books:

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

Suggested e-learning materials:

1. Wastewater Management
   https://nptel.ac.in/courses/105105048/

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

ENVS 514L Environment Lab-III

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**0**	**0**	**12**	**6**

Learning Outcomes:

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

- Illustrate physical and chemical characterization of waste.
- Illustrate the process of vermiculture.
- Enlist major steps of Environmental Impact Assessment (EIA) process.
- Determine sound level from various sources.

Course Content:

1. Determination of Flouride in water sample.
2. Determination of Sulphate in water sample.
3. Physical characterization of solid waste / refuse.
4. To determine COD in waste water samples.
5. Determination of VSS and TSS in soil/sludge samples
6. Determination of available Phosphorous in soil/sludge samples

7. EIA methods in Solid waste disposal- Leopold matrix and overlay.
8. To measure the intensity of sound from different sources.
9. To analyze Particulate matter in air samples.
10. To analyse SO_2 in air samples.
11. To analyse NO_2 in air samples.
12. To estimate Proline in plant leaves.
13. To record and analysis of climate trends by taking meteorological data of rainfall and temperature.
14. Construct the composting pit.
15. Construct the pit for vermiculture.
16. Planning and design of landfill sites.
17. Study of biogas plant.
18. Field Survey

Recommended Books:

1. Lakshmi, G. S. (2012). *Environmental Science : A Practical Manual*. Delhi, India: B.S.
2. Maiti, S.K. (2011). Handbook of Methods in Environmental Studies. Vol. 1: Water and Wastewater Analysis. Jaipur, India: Oxford Book Company.
3. Maiti, S.K. (2011). Handbook of Methods in Environmental Studies. Vol. 2: Soil and Air Analysis. Jaipur, India: Oxford Book Company
4. Narasalah, G. L. (2012).Environmental Science : A Practical Manual. Delhi, India: B.S.

Suggested e-learning materials:

1. Environmental Science, http://download.nos.org/333coursee/prac_manual.pdf
2. Virtual Lab

   http://www.vlab.co.in/
3. Environmental Science Basics

   https://www.nios.ac.in/online-course-material/sr-secondary-courses/enviornmental-science-(333).aspx

Fourth Semester

ENVS 516P Project

Max. Marks : 100	L	T	P	C
(CA: 40 + ESA: 60)	0	0	48	24

Learning Outcomes:

After completion of this course students should be able to:

- Demonstrate competence for independent work in the field of Environmental Science and Technology.
- Develop competency in, collection, classification, interpretation
- Develop skills to analysis the collected data.
- Handle the complex tasks of lab experiments including project report writing.

Discipline Electives

ENVS 503 Biotechnology Application to Environmental Science

Max. Marks : 100	L	T	P	C
(CA: 40 + ESA: 60)	4	0	0	4

Learning Outcomes:

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

- Describe heavy metal pollution and outline control measure of global warming.
- Describe ozone depletion, acid rain and nuclear accidents
- Describe biosensor development to monitor pollution.
- Explain the management of sludge and biodegradation of hydrocarbons.

Course Content:

Section A

Definition and Scope of Environmental Biotechnology

Environmental Pollution; Types, Causes and Effects of Soil, air, water, oil and heavy metal. Pollution, control measures.

Social Issues- Green House Gases, Global Warming, Acid Rain, Ozone depletion, nuclear accidents and holocaust.

Purification of waste water; Aerobic and anaerobic treatments; Laboratory methods for the detection of coli form organisms in water; Water recycling methods; Management of radioactive pollutants in water, VOC, COD BOD and BOD sensors.

Section B

Molecular biology tools for Environmental management, rDNA technology in waste treatment, Genetically modified organisms in Waste management, Genetic Sensors, Metagenomics, Bioprospecting, Nanoscience in Environmental management, Phytoremediation for heavy metal pollution, Biosensor development to monitor pollution.

Biomass waste as renewable source of energy, Cellulose and Hemi cellulose as source of energy Biocomposting, Vermiculture, Biofertilizers, Organic farming, Biofuels, Biomineralization, Bioethanol and Biohydrogen,

Section C

Bioelectricity through microbial fuel cell, Conversion of Solid Waste to Methane; Biogas production, Management of Sludge and Solid waste treatment- Land filling, lagooning, Ecofriendly agriculture.

Definition, Types- Ex situ and In situ Bioremediation; genetically Engineered Microbes for Bioremediation; Bioremediation of Ground Water;

Biodegradation of Hydrocarbons, Pesticides, Herbicides, Insecticides and Xenobiotics.

Recommended Books:

1. Chakraborty, K. D., & Omen, G. S. (1989). *Biotechnology and Bio degradation*, Advances in Applied Biotechnology series. London, UK:Gulf.
2. Rittmann, B. E. (2018). *Environmental Biotechnology*. New York, NY: Mcgraw-hill education.

3. Sharma, D. L. (2002). *Organic farming*. Rajasthan: India: Agro-Bios.

4. Thakur, I. S. (2006). *Environmental Biotechnology- Basic concepts and Applications*. New Delhi, India: I K International.

Suggested e-learning materials:

1. Nanobiotechnology in Environment
   https://nptel.ac.in/courses /102103045/download/mod6.pdf
2. Biotechnology
   https://nptel.ac.in/courses/118107015/33
3. Gene therapy in the treatment of disease
   https://nptel.ac.in/courses/102103013/39

ENVS 504 Disaster Management and Mitigation Strategies

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

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

- Explain natural and manmade disaster and associated socio economic impact.
- Discuss key concepts, definitions and perspectives of disaster Management
- Describe the Disaster Management Cycle.
- Describe planning for hazard mitigation.

Course Content:

Section A

Introduction to Disaster and Hazards

Hazards and Disaster: Definition and Difference; Types of Hazards and Disaster; causes and consequences, Prediction and Indicators of Natural Disasters, Natural Disasters – Earthquakes, Cyclones, Floods, Drought and Landslides, Man Made Disaster – Nuclear and Chemical

Section B

Impact of Disaster and Case Studies

Social, Economic and Health impacts of Disaster, Floods - one case study with special reference to Brahmaputra Basin, Drought – one case study with special reference to Vidarbha and Telangana region, Earthquake – one case study with special reference to Himalayan region, Nuclear – Hiroshima and Nagasaki

Section C

Natural Disaster Management and Preparedness

Disaster Management: Prevention, Preparedness and Mitigation, Planning and control of Natural Disaster, National and State level planning for Hazard Mitigation, Role of Natural Disaster Management Authority

Recommended Books:

1. BMTPC & CDMM (2003). *Landslide Hazard Zonation of India*. New Delhi, India.
2. Decker, R. W. & Decker, B. B. (1998): *Volcanoes* (3rd ed.).NY, New York: WH Freeman & Company.
3. Dowrick, D. (2003). *Earthquake Risk Reduction Zone*.Sushex, England: Wiley & Sons.
4. Drake, F. (2000). *Global Warming the Science of Climate Change*. New York, NY: Oxford University Press.
5. Gere, J. M. & Shah, H.C. (1984). *Terra Non Firme Understanding and Preparing for Earthquakes*. New York, NY: WH Fremman & Company.
6. Govt. of India, (2002). *Drought 2002 a Report (part I), Ministry of Agriculture, Dept. of Agriculture and Cooperation*. New Delhi, India.
7. Govt. of India, (2002). *Drought 2002 States Report (part II), Ministry of Agriculture, Dept. of Agriculture and Cooperation*. New Delhi, India.

8. Govt. of India, (2004). *Annual Reports, Ministry of Agriculture, Dept. of Agriculture and Cooperation*, 1999-2000, 2002-2003, 2003-2004. New Delhi, India.

9. IGNOU (2005). *Understanding Natural Disasters*. Noida, India: Shagun Offset Press.

10. IMD (1972) *Cyclone and safeguards.* New Delhi, India.

11. Inca, M. (1990). *The Rising Seas*. London, UK: Earthscan.

12. Prakash, I. (1994).*Disaster Management.*Ghaziabad, India: RastriyaPrahari.

13. Roy, S. (2004). *Natural Disaster Management – a case study of Tornado*. New Delhi, India:Abhijit.

14. Savindra, S. (2015). *Environmental Geography*. Allahabad, India: Pravika.

15. Sharma, V. K. (1995). *Disaster Management.* New Delhi, India: IIPA.

16. Singh, T. (2006). *Disaster Management Approaches and Strategies*. New Delhi, India: Akanksha.

17. Sinha, D. K. (2006). *Towards Basics of Natural Disaster Reduction*. New Delhi, India:Reasearch.

18. Thomas, B. (1993). *Disaster Response: A Handbook for Emergencies*. New Delhi, India: CASA.

Suggested e-learning materials:

1. Disaster Management
   https://swayam.gov.in/courses/4983-disaster-management

2. Natural and Man-Made Environment and Disasters
   https://nptel.ac.in/courses/122102006/9

3. Floods and Cyclones
   https://www.sac.gov.in/SACSITE/SAC-Flyers/menulinks/society/9.1%20FLOODS%20&%20CYCLONES.pdf

4. Surface and Ground water resources
   https://nptel.ac.in/courses/ 105105110/pdf/m6l02.pdf
5. Introduction to Engineering Seismology
   http://nptel.ac.in/courses/ 105108076/module6/lecture16.pdf

ENVS 505 Energy Auditing and Conservation

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

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

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

Course Content:

Section A

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

Section B

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

Section C

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

Recommended Books:

1. Abbi, Y.P., & Jain S. (2006). *Handbook on Energy Audit and Environment Management*. Delhi, India: TERI Press.
2. Goswami, D. Y., & Frank K. (2015). *Energy Efficiency & Renewable Energy Handbook*. Florida,Fl: CRC Press (Taylor & Francis Group).
3. Polimeros, G., (1981). *Energy Cogeneration Handbook*. New York, NY: Industrial Press.
4. ThrelkeldJ, L. (1970): *Thermal Environmental Engineering* (2nd Ed.). New Jersey, NJ: Prentice Hall.
5. Trinks, W., Mawhinney, M. H., Shannon, R. A. & Reed, R. J., & Garvey J. R. (2003). *Industrial Furnaces* (6thed.). New Jersey, NJ:John Wiley & Sons.
6. Turner, W. C. (2007). *Energy Management Handbook* (7thed.). Georgia, USA: Fairmont Press.

7. Witte, L. C., Schmidt, P. S., & Brown, D. R. (1998). *Industrial Energy Management and Utilization*. Washington, WA: Hemisphere.

Suggested e-learning materials:

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

ENVS 507 Environmental Health Management

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

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

- Explain the concept of environmental health.
- Identify different environmental factors that affect health.
- Discuss the preventive and protection measures for various water borne diseases.
- Describe the seasonal changes and protection measures for various air borne bio-allergen.

Course Content:

Section A

Meaning of health: Physical, Mental and Social, Environmental factors influencing health: Urbanization & congestion, pollution.

Environmental health criteria, Concept of environmental health management

Section B

WHO classification of diseases and their distribution: Water borne diseases;

Prevention and protection of community health from water borne diseases. Air borne bio-allergents; present in the ambient air, seasonal changes, mode of dispersal, disease intensity and control.

Section C

Effects of Physical Environment on Accidents, Crime, Suicide and Diseases of Man

Effects of temperature, humidity, ionization, ultra violet radiation and acidity of air on skin, lungs, throat, nose, eye, nervous system.

Effects of weather and climate on diseases, mental processes, working efficiency, traffic and industrial accidents, behaviour, suicide and suicide attempts, effect of thermal stress and altitude on the action of drug.

Recommended Books:

1. Abdul, M. et.al. (2014). *Environmental Deterioration and Human Health.* Dordrecht Heidelberg London, England: Springer.
2. Ahluwalia, V. K. (2015). *Environmental Pollution and Health*. New Delhi, India:TERI.
3. Annalee, Y. et.al. (2001). *Basic Environmental Health.* New York, NY: Oxford University Press.
4. Kathryn, H. (2006). *Environmental Health Ecological Perspective*. Sudbury, Massachussetts, MA: Jones & Bartlett.
5. Robert, H. F. (2012). *Essentials of Environmental Health*(2nd ed.). Sudbury, Massachussetts, MA: Jones & Bartlett.
6. Singh, A. L. (2010). *Environment and Health*. New Delhi, India:B.R.

Suggested e-learning materials:

1. Indoor Environmental Delhi

   http://textofvideo.nptel.ac.in/112107208/lec38.pdf

2. Introduction to Environmental Health

   http://ocw.jhsph.edu/courses/environmentalhealth/lectureNotes.cfm

3. The effects of temperature on human health

   https://www.oulu.fi/sites/default/files/content/Ikaheimo_TM_Temperature_and_human_health_28102014.pdf

ENVS 508 Environmental Impact Assessment and Management

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

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

- Describe Scope of Environmental Impact Assessment and its Objectives.
- Describe various approaches for various environmental impact studies
- Illustrate various steps of Environmental Impact Assessment and its methodologies.
- Construct Environmental Impact Assessment plan for Industrial projects

Course Content:

Section A

Introduction:

Historical development of Environmental Impact Assessment (EIA)

Definition and scope of EIA, Objectives of EIA, Basic EIA principles.

Impact study:

Approach for environmental impact studies, EIA as planning tool

EIA Methodology, Predictive model of impact assessment.

Section B

Impact Prediction and assessment for air, water and noise:

Air: Knowledge of air quality, Air quality standards, Sources of pollutants,

Effects of pollutions, Conceptual approach for air impacts prediction.

Water: Information on water quality (Surface water and ground water), water quality standards, Identification and prediction of impact and assessment.

Noise: Information on noise legislation and guidelines, Methodology for noise-impacts prediction, Assessment of impact significance.

Section C

Environmental Risk Assessment (ERA) and Management in EIA:

Environmental risk assessment, treatment of uncertainty, key steps.

Management Plan: Impact prediction, evaluation and mitigation

Preparation of EIA plan for industrial project and functions

Factors for consideration, managing the EIA process, Monitoring and auditing.

Recommended Books:

1. Anjaneyulu, Y. (2003). *Environmental Impact Assessment* (2nd ed.). Hyderabad, India: B.S.
2. Attri S. D., & Tyagi A. (2010*). Climate Profile of India*. Ministry of Earth Sciences, New Delhi, India
3. Glasson J., Therivel R. & Chadwick A. (1999). *Introduction to Environmental Impact Assessment*(4th ed.). London, UK: Routledge.
4. Lawrence, D. P. (2003). *Environmental Impact Assessment – Practical solutions to recurrent problems.*New Jersey, NJ:Wiley-Interscience.
5. Petts, J. (1999). *Handbook of Environmental Impact Assessment*. New Jersey, NJ: Blackwell Science.

Suggested e-learning materials:

1. Environment Impact Assessment
   http://www.moef.nic.in/division/introduction-8
   https://nptel.ac.in/courses/120108004/module3/lecture3.pdf
2. EIA Documentation and Processes
   https://nptel.ac.in/courses/120108004/module4/lecture4.pdf
3. EIA, EMP and EA
   https://nptel.ac.in/courses/123105001/36

ENVS 407 Environmental Physics

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

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

- Apply the concepts and laws of physics that govern the environment.
- Measure different environmental parameters.
- Describe applications of laser and detection of environmental pollutants by laser absorption.
- Describe LiDAR technique and its applications.

Course Content:

Section-A

The scope of environmental physics

Laws of thermodynamics, reversible and irreversible thermodynamical process and entropy, Specific heats, Gas Laws for isothermal and adiabatic processes, Lapse rate

Water and Water Vapour: vapour pressure, dew point, saturation vapour pressure deflect, specific and relative humidity, Transport laws: General transfer equation, molecular transfer process, diffusion coefficients

Radiation Laws: black body radiations, Wien's law, Stefan's law, Planck's law, Cosine law for emission and absorption, reflectivity, radiance and irradiance, Wind chill, Hypothermia

Section-B

Radiation Environment- Solar Radiation: solar constant, sun-earth geometry, attenuation in the atmosphere, solar radiation at the ground; Terrestrial Radiation; Cloudless skies, Cloudy skies, Microclimatology of radiations (interception): Direct and diffused solar radiations, Shape factors, canopies of black leaves, Microclimatology of radiations (absorption and reflection): radiative properties of natural materials

Section-C

Laser applications, Laser light transmission through the atmosphere, molecular absorption and particle scattering techniques for detection of molecules of pollutants by absorption of laser, Remote monitoring capabilities of laser systems, LIDAR technique and its applications, Microwaves; Environmental aspects of microwave radiations, Microwave decomposition of toxic vapour stimulants.

Recommended Books:

1. Garg, S. C., Bansal, R. M., & Ghosh, C. K, (2017*). Thermal Physics.* New Delhi, India: McGraw Hill.
2. John, M. L. & Unsworth M. H. (2013). *Principles of Environmental Physics* (4th ed.).London, UK: Academic Press.
3. Wei, G., Schmoldt, D., & Slusser J. R. (2010). *UV Radiation in Global Climate Change: Measurements, Modeling and Effects on Ecosystem*. Netherland: Springer
4. Boeker, E., & Van Grondelle, R. (2011). *Environmental physics: sustainable energy and climate change*(3rd ed.). New Jersey, NJ: John Wiley & Sons.

Suggested e-learning materials:

1. Laws of Thermodynamics
   https://onlinecourses.nptel.ac.in/noc17_mm16/preview

2. Radiation heat radiation
   https://nptel.ac.in/courses/112108149/pdf/M9/Student_Slides_M9.pdf
3. An introduction to underground mine environment and ventilation
   https://nptel.ac.in/courses/123106002/MODULE%20-%20III/Lecture%201.pdf
4. Lidar basic principles and applications
   https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000017GE/P001697/M024733/ET/1509971402LIDARbasicprincipleandapplications(1.pdf

ENVS 518 Concepts of Atmosphere, Geochemistry and Oceans

Max. Marks : 100	**L**	**T**	**P**	**C**
(CA: 40 + ESA: 60)	**4**	**0**	**0**	**4**

Learning Outcomes:

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

- Explain the various phenomenon of atmosphere.
- Identify the factors involved in changing weather and climate conditions.
- Discuss the components of land components and its chemistry.
- Describe the characteristic of oceans and its chemistry .

Course Content:

Section A

Different layers and their characteristics, Meteorological aspects-inversions, mixing height, wind rose, electromagnetic radiations, solar radiations and terrestrial radiations, heat budget, Temperature measurements and controls, Environmental lapse rate and atmospheric stability, atmospheric transport, diffusion and dispersion, mixing ratio, atmospheric moisture and humidity, clouds type and their characteristics, elements of weather and climate classification, Atmospheric general circulation, precipitation and types of storms, Indian monsoon, western disturbances, geostrophic wind and

gradient wind, Air masses and fronts, jet streams, flood and droughts, Aerosol-Cloud interaction.

Section B

Components of the Earth System, concept of major, minor and trace elements, mobility of elements, hydrologic and biogeochemical cycles, resources and reserves, mineral resources of Rajasthan, soil composition, Carbon flux and photosynthesis, vegetation dynamics, landscape heterogeneity, Land-use/land-cover changes.

Section C

Characteristics of ocean basins, properties of sea water, Mixed layer and heat budgets of the ocean, Ekman dynamics, upwelling and down welling processes, Chemical property and composition of sea water, marine biogeochemical cycles.

Recommended Books:

1. Bonan, G. (2008). *Ecological Climatology: Concepts and Applications*. 2nd Edition, Cambridge.
2. Botkin, D.B., &Keler Edward, A. (2007). *Environmental Science: Earth as a living planet.* 6th ed. John Wiley& Sons.
3. Eby, N. (2003). *Principles of Environmental Geochemistry*. Brooks Cole, USA.
4. Gary, E. T., & Knut, S. *Radiative Transfer in the Atmosphere and Ocean*.Cambridge Atmospheric and Space Science Series.
5. Kemp, MJ. (1997). *Environmental Science*. The McGraw-Hill Companies.
6. Maarten, H. P., &Ambaum. *Thermal Physics of the Atmosphere* (Advancing Weather and Climate Science) Wiley.
7. Neil, C. *The Atmosphere and Ocean: A Physical Introduction*(Advancing Weather and Climate Science), Wiley.
8. Reven, P.H., Berg, L.H., &Hassenzahl, D.M. (2008). *Environment*. 6th ed. John Wiley & Sons., USA.
9. Riehl, H. (1979). *Climate and Weather in the Tropics*.Academic Press.
10. Shuttleworh, W. J. (2012). *Terrestrial Hydrometeorology*. 1st Edition, John Wiley & Sons.

Suggested e-learning materials:

1. Introduction to Atmospheric Science
   https://nptel.ac.in/courses/119/106/119106008/
2. Physics of Atmosphere and oceans
   https://nptel.ac.in/courses/119/102/119102007/
3. The monsoon and its variability
   https://nptel.ac.in/courses/119/108/119108006/

Reading Electives

ENVS 512R Agroforestry

Max. Marks : 100	**L**	**T**	**P**	**C**
(ESA: 100)	**0**	**0**	**4**	**2**

Learning Outcomes:

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

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

Course Content:

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

Recommended Books :

1. Chundawat, B. S., & Gautam, S. K. (2016). *Textbook of Agroforestry*. New Delhi, India: Oxford & Ibh.
2. Jose, S. (2009). *Agroforestry for Ecosystem Services and Environmental Benefits (Advances in Agroforestry)*. Dordrecht Netherlands: Springer

3. Mukherjee, A. (2016). *Agroforestry and Watershed Management: An Interlocked System.* New Delhi, India: Random.

4. Raj, A. J. (2017). *Agroforestry Theory and Practices*. Jodhpur, India: Scientific.

Suggested e-learning materials:

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

ENVS 513R Energy Resources and Conservation

Max. Marks : 100	**L**	**T**	**P**	**C**
(ESA: 100)	**0**	**0**	**4**	**2**

Learning Outcomes:

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

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

Course Content:

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

Label, Modes of Energy Conservation in residential, industrial and transportation sector.

Recommended Books :

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

Suggested e-learning materials:

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

ENVS 515R Man and Environment

Max. Marks : 100	**L**	**T**	**P**	**C**
(ESA: 100)	**0**	**0**	**4**	**2**

Learning Outcomes:

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

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

Course Content:

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

Recommended Books :

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

Suggested e-learning materials:

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

ENVS 517R Water and Sustainable Development

Max. Marks : 100	**L**	**T**	**P**	**C**
(ESA: 100)	**0**	**0**	**4**	**2**

Learning Outcomes:

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

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

Course Content:

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

Recommended Books :

1. Asawa, G. L. (2005). *Irrigation and Water Resources Engineering*, New Delhi, India: New Age.

2. Biswas, A. K., Jellau, M., & Stout, G. (1993). *Water for sustainable development in 21st century – A Global perspective*, Oxford, UK: Oxford University Press.

3. David, L. F. (2007). *Water Policy for Sustainable Development*. Baltimore, Maryland: Johns Hopkins University Press.

4. Jain, S. K., & Singh, V. P. (2003). *Water Resources Systems Planning and Management*. Amsterdam, Netherlands: Elsevier.

Suggested e-learning materials:

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

GEOG 513R Environmental Challenges and Disaster Management

Max. Marks : 100	**L**	**T**	**P**	**C**
(ESA : 100)	**0**	**0**	**4**	**2**

Learning Outcomes:

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

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

Course Content:

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

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

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

* Note – Stencils are to be permitted during the examination.

Recommended Books:

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

Suggested e-learning materials:

1. Deforestation:- Concept, Causes, Effects
   https://www. livescience.com/27692-deforestation.html
2. Acid Rain:- Causes, Consequences and mitigation measures
   https://www.conserve-energy-future.com/causes-and-effects-of-acid-rain.php

3. Solid Waste:- Introduction, Types and Management https://www.indiawaterportal.org/topics/solid-waste

GEOG 514R India: Socio-Political and Environmental Scenario

Max. Marks : 100	**L**	**T**	**P**	**C**
(ESA: 100)	**0**	**0**	**4**	**2**

Learning Outcomes:

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

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

Course Content:

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

Recommended Books :

1. Deshpande, C. D. (1992*). India, A Regional Interpretation*. New Delhi, India: ICSSR & Northern Book Centre.
2. Gallaher, C. et al. (2012). *Key Concepts in Political Geography* (Reprint). New Delhi, India: Sage.
3. Hussain, A. (2007). *Political Geography.* New Delhi, India: Vishvabharti.

4. Singh, R. L. (Ed.).(1971). *India - A Regional Geography*. Varanasi, India: National Geographical Society.
5. Tirtha, R., & Gopal, K. (1996). *Emerging India.* Jaipur, India: Rawat.
6. बंसल, एस. सी. (2011). *भारत का भूगोल.* मेरठ, भारत: मीनाक्षी.

Suggested e-learning materials:

1. Interlinking of rivers
   https://www.geoecomar.ro/website/publicatii/Nr.19 2013/12_mehta_web_2013.pdf
2. Farmer suicides
   http://www.ipcinfo.org/fileadmin/user_upload/fsn/docs/Agriculture%20and%20rural%20development%20in%20India.pdf
3. Food Security
   https://dfpd.nic.in/LwB3AHIAaQB0AGUAcgBlAGEAZABkAGEAdABhAC8AUABvAHIAdABhAGwALwBNAGEAZwBhAHoAaQBuAGUALwBEAG8AYwB1AG0AZQBuAHQALwA=1_93_1_Original.pdf
4. Gender Issues in India
   https://www.indiacelebrating.com/social-issues/gender-inequality-in-india/

GEOG 515R Rajasthan: Challenges and Prospects

Max. Marks : 100	**L**	**T**	**P**	**C**
(ESA: 100)	**0**	**0**	**4**	**2**

Learning Outcomes:

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

- Describe the major environmental, socio economic problems of Rajasthan.

- Explain desertification, Aravalli development, agriculture and tourism of Rajasthan.
- Analyze existing state and national policies in terms of socio economic conditions.
- Aware society regarding existing policies related to child marriage, Female feticide and other Social problems.

Course Content:

Major Canal Irrigation Project and Its impact; Desertification and Desert Development programmes; Identification of drought prone areas and mitigation, problem of mining and Aravalli Development Programme, Problems and measures of Agricultural development; Programmes for forest conservation; Poultry farming, Planning for livestock development; Role of Tourism in the economy.

Socio- economic issues and Government policies and programmes: child marriage, female feticide, female education, gender discrimination and caste; unemployment and poverty.

Recommended Books :

1. Singh, G. (2010). *Geography of India* (9th ed.). Delhi, India: Atma Ram.
2. शर्मा, आर. (2010). *राजस्थान का भूगोल.* उदयपुर, भारत: हिमाशुं.
3. शर्मा एच. एस., एवं शर्मा, एम. एल. (2015). *राजस्थान का भूगोल.* जयपुर, भारत: पचंशील.
4. सक्सैना, एच. (2014). *राजस्थान का भूगोल.* जयपुर, भारत: राजस्थान हिन्दी ग्रंथ अकादमी.

Suggested e-learning materials:

1. Indira Gandhi Canal
   https://www.rajras.in/index.php/indira-gandhi-canal/
2. Tourist spots in Rajasthan

http://www.transindiatravels.com/rajasthan/tourist-places-to-visit-in-rajasthan/

3. Problem of Desertification
http://www.cazri.res.in/annals/1993/1993JA-1.pdf.

GEOG 517R Transforming India

Max. Marks : 100	**L**	**T**	**P**	**C**
(ESA: 100)	**0**	**0**	**4**	**2**

Learning Outcomes:

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

- Assess the ongoing governmental policies applicable to socio-economic and health sectors.
- Aware society about the injustice caused to Women in terms of Triple Talaq.
- Explain current livelihood struggle in the society and the role of skill development in enhancing quality of life.
- Suggest the measures of improvement in the policies.

Course Content:

Transforming India into a digitally empowered society and development through digitalization, its effects and problems. Demonetization- a step to less cash to cash less economy. Indian youth as a change agent and quality of education for empowering Indian youth, Skill development and empowering youth, Population pressure in job sector and creating livelihood opportunities. Swachh Bharat Mission and Sanitation revolution for clean and healthy society, Ayushman Bharat Yojana- a step towards Health for all. Beti Bachao - Beti Padhao- a step for girl's development and Triple Talaq in India- an injustice for women or religious issue.

Recommended Books :

1. Ghosh, J., Chandrashekra, C. P., & Patnaik, P. (2017). *Demonetisation Decoded*. New York, NY: Routledge.

2. Panigrahi, R. L. (2005*). Population problems in India*. New Delhi, India: DPH.

3. Sinha, M., & Sinha, R. K.(Ed). (2008). *Swachh Bharat, A clean India*. New Delhi, India: Prabhat.

Suggested e-learning materials:

1. Transforming India
   http://transformingindia.in/
2. Digital India
   https://www.indianeconomy.net/splclassroom/what-is-digital-india/
3. Demonetization
   http://www.mbauniverse.com/group-discussion/topic/business-economy/demonetisation
4. Skill Development in India
   https://www.indiainfoline.com/article/article-latest/skill development-in-india-gaps-and-opportunities 118092700366_1.html
5. Swachh Bharat Mission
   https://www.mapsofindia.com/my-india/society/swachh-bharat-abhiyan-making-india-clean-more
6. Beti bachao and Beti Padhao
   http://www.mbauniverse.com/group-discussion/topic/social-issues/beti-bachao-beti-padhao

GEOL 514R Geo Tourism

Max. Marks : 100	**L**	**T**	**P**	**C**
(ESA: 100)	**0**	**0**	**4**	**2**

Learning Outcomes:

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

- Elucidate the criterion require for designating geotour sites.

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

Course Content:

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

Recommended Books :

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

Suggested e-learning materials

1. UNESCO geological heritage and geo-tourism in Peru http://www.unesco.org/new/en/media-services/single view/news/unesco_geoparks_geological_heritage_and_geo_tourism_in_peru/
2. Geotourism

https://link.springer.com/referenceworkentry/10.1007%2F978-3-319-01669-6_93-1

3. Geotourism in India
https://www.gsi.gov.in

GEOL 517R Indian Mineral Deposits, Economics and Mining Ethics

Max. Marks : 100	**L**	**T**	**P**	**C**
(ESA: 100)	**0**	**0**	**4**	**2**

Learning Outcomes:

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

- Explain the distribution of mineral resources in India.
- Evaluate the mineral resources and reserves in Indian and global perspective.
- Familiarize with the concept of mineral legislation and policies.
- Delineate the different environmental issues associated with mining activities.

Course Content:

Introduction to types and distribution of various mineral deposits in India. Occurrences of important metallic, non-metallic/industrial and fuel mineral deposits of India. Mineral economics and its major concept. Introduction for Global mineral resources. Conservation and substitution of minerals; changing pattern of mineral consumption, Growth of mineral industry and economy, Mineral industry and its adverse effect to the environment. Environmental baseline data needed for mine planning-Its acquisition and documentation during different stages of exploration. Nature and extent of environmental problems due to surface and underground mining. Legislation and control measures for mining. Mineral legislation in Indian context (The Mines and Minerals Regulation and Development Act, 1957). Reclamation and restoration of mined land.

Recommended Books :

1. Arogyaswamy, R. N. P. (1995). *Courses in Mining Geology* (4th ed.). New Delhi, India: Oxford and IBH.
2. Banerjee, D. K. (1998). *Mineral Resources of India* (2nd ed.). Kolkata, India: The World Press.
3. Chatterjee, K. K. (1993). *An Introduction to Mineral Economics* (2nd ed.). Bangalore, India: New Age International (p) Ltd.
4. Sharma, N. L., & Ram, K. S. V. (1964). *Introduction to India's economic minerals*. Dhanbad, India: Dhanbad Publishers.
5. Sinha, R. K., & Sharma, N. L. (1988). *Mineral Economics* (4th ed.). New Delhi, India: Oxford & IBH.

Suggested e-learning materials:

1. Mineral and energy resources
   http://ncert.nic.in/ncerts/l/legy207.pdf
2. Economic Minerals of India
   https://www.researchgate.net/publication/315831629_Economic_Minerals_of_India

GEOL 518R Innovation and Entrepreneurship in Earth Sciences

Max. Marks : 100	**L**	**T**	**P**	**C**
(ESA: 100)	**0**	**0**	**4**	**2**

Learning Outcomes:

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

- Understand necessary steps to open a new venture.
- Gain an understanding of creating products or services, launching innovative projects and making R&D investments in a start-up context.

- Develop marketing strategies for tools and technical products used in earth sciences.
- Familiarize with the legal concepts and financial planning for a successful new venture.

Course Content:

An overview of Entrepreneurs and Entrepreneurship. Evolution and Growth of Earth Science. Entrepreneurship in India, Starting small business. Planning-Organization and Management. Basic layout of Proposal for seeking loan from financial institution, Legal requirements, Basic Financial Planning and problems. Case study of successful Earth Science Entrepreneurs in India Earth Science component in Government of India PSU (MECL, NHPC Mini Ratna, ONGC, NTPC, CIL Maharatna) and in MNC (Larsan and Tourbo, Tata, Reliance, Vedanta, Dalmiya groups, Aditya Birla). Entrepreneurs Skills and Competencies. Earth Science technology for harnessing Innovation. Challenges of new startups, Marketing Strategies development Tools and techniques for market Assessments, Methods and sources for market survey and Market Information. Presentation of Market Survey Report.

Recommended Books :

1. Clarysse, B. (2011). *The Smart Entrepreneur: How to Build for a Successful Business*. London, UK, Elliott & Thompson.
2. Sethi, A. (2016). *From Science to Startup: The Inside Track of Technology. Entrepreneurship*. Göttingen, Germany: Copernicus & Springer.
3. Westhead, P., & Wright, M. (2013). *Entrepreneurship. A very short introduction*. Oxford, UK: Oxford University Press.

Suggested e-learning materials:

1. Sustainability, Innovation and Entrepreneurship https://nptel.ac.in/courses/110107094/26
2. New Enterprises

https://ocw.mit.edu/courses/sloan-school-of-management/15-390-new-enterprises-spr

GEOL 521R Natural Hazards and Disasters

Max. Marks : 100	**L**	**T**	**P**	**C**
(ESA: 100)	**0**	**0**	**4**	**2**

Learning Outcomes:

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

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

Course Content:

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

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

Recommended Books :

1. Bolt, B. A. (1988). *Earthquakes.* New York, NY: WH Freeman & Company.

2. Decker, R. W. & Decker, B. B. (2005). *Volcanoes* (4th ed.). New York, NY: WH Freeman & Company.

3. Dowrick, D. (2003). *Earthquake Risk Reduction Zone.* England, UK: John Wiley & Sons.

4. Gere, J. M., & Shah, H. C. (1984). *Terra Non Firme Understanding and Preparing for Earthquakes.* New York, NY: WH Freeman & Company.

5. IGNOU (2005). *Understanding Natural Disasters*. eGyanKosh, Noida, India: Shagun Offset Press.

6. Keller, E. A., & Devecchio, E. D. (2015). Natural Hazards (4th ed.). New York, NY: Pearson.

7. Keller, E.A. (1978). *Environmental Geology* (9th ed.). North Corelina, NC : Bell & Howell.

8. Montgomery, C.W. (2013). *Environmental Geology* (10th ed.). New York, NY : Mc-Graw-Hill.

9. Prakash, I. (1994). *Disaster Management*. Ghaziabad, India: Rastriya Prahari.

10. Sharma, V. K. (1995). *Disaster Management*. New Delhi, India: Indian Institute of Public Administration *(*IIPA*)*.

11. Singh, S. (2015). *Environmental Geography*. Allahabad, India: Pravalika.

Suggested e-learning materials:

1. Introduction to Natural hazards
   https://epgp.inflibnet.ac.in/ahl.php?csrno=17
   https://onlinecourses.nptel.ac.in/noc19_ce14/preview

2. Disasters and Hazards
   https://ndma.gov.in/en/

GEOG 518R Health, Space and Ecology

Max. Marks : 100	L	T	P	C
(ESA: 100)	0	0	4	2

Learning Outcomes:

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

- Analyze and explain concepts of mortality, morbidity and health.
- Explain the distribution of major communicable and non-communicable diseases in India.
- Develop an understanding of the structure of health care services in India.
- Explain and analyze the Public and Private Initiatives in health-care provisions and also about Health Policies and Programmes running in India.

Course Content:

Concept of mortality, morbidity and health; Colonial and Post- Colonial conception of health and medicine; Health as a commodity; Health and Quality of life; Linkage between health and ecology; Pattern of morbidity- world and India; Geographical aspect of distribution of major diseases in India- communicable (HIV/AIDS, Tuberculosis (TB) and non-communicable (Malaria, Cholera); Regional variation in Prevalence of diseases; Sources of infection, modes of transmission; Structure of health care services in India; Health inequality; Problems of access and utilization; Public and Private Initiatives in health-care provisions; Health Policies and Programmes in Independent India.

Recommended Books:

1. Akhtar, R. (Ed). (2016). Climate Change and Human Health Scenario in South and Southeast Asia. New Delhi, India: Springer Nature.
2. Choudhary, B.K. (2008). Tuberculosis in India: A Political Ecology Approach. Riga: VDM Verlag.

3. Farmer, P. (1999). Infection and Inequalities: the modern Plagues. Berkeley: University of California Press.
4. Lankinen, S.K. (Ed). (1994). Health and disease in Developing Countries. London: Macmillan Education Ltd.
5. May, J. M. (1970). The World Atlas of Diseases. New Delhi, India: Nat Book Trust.
6. Naidoo, J., Wills, J. (2001). Introduction to Health Studies. NY: Pal grave.
7. Park, J. E., & Park, K. (2007). Preventive and Social Medicine. (19thed.).Jabalpur, India: M/s Banarsi das.
8. Park, J. E., & Park, K. (2014). Text Book of Community Health for Nurses. Jabalpur, India: Ansari.
9. Phillips, D.R., Varhasset, Y. (Ed). (1994). Health and Development. London: Routledge.
10. सिंधई, जी. सी. (2010). चिकित्साभूगोल(द्वितीय सं.). गोरखपुर, भारतः वसुन्धरा.

Suggested e-learning materials:

1. Family Welfare programme in India
   http://planningcommission.nic.in/plans/mta/mta-9702/mta-ch17.pdf
2. Public and Private Initiatives in health-care provisions
   https://www.who.int/healthsystems/topics/financing/healthreport/P-P_HSUNo39.pdf
3. Geographical aspect of distribution of major diseases in India-communicable and non- communicable

http://planningcommission.nic.in/aboutus/committee/wrkgrp12/health/WG_3_2non_communicable.pdf

List of Alternative Online Reading Electives

Students can opt alternative online courses for the following reading electives:

S. No.	Courses	Alternative online course	Agency/ Portal	Credit point(s)	New URL
1	ENVS 513R Energy Resources and Conservation	Non-Conventional Energy Resources	Indian Institute of Technology Madras, NPTEL	2	https://nptel.ac.in/courses/121/106/121106014/
2	GEOL 517R Indian Mineral Deposits, Economics and Mining Ethics	Mineral Resources: Geology, Exploration, Economics and Environment	Indian Institute of Technology Roorkee, NPTEL	2	https://nptel.ac.in/courses/105/105/105105170/
3	GEOL 521R Natural Hazards and Disaster	Natural Hazards Part 1	Indian Institute of Technology Kanpur, NPTEL	2	https://nptel.ac.in/courses/105/104/105104183/