M.Sc. PART II
DETAILED SYLLABUS

(Theory: 15 Lecture hours= 1 Credit & Practical: 30; Lecture hours= 1 Credit;

SEMESTER III

Theory / Practical	Paper Code	Course Title	No. of Credits	No. of Lectures	Total Credits
Theory	US-MLSC-301	Environment and Pollution	3	45	8+4=12 (Major)
Practical	US-MLSC-P301	Practicals based on Environment and Pollution	1	30	
Theory	US-MLSC-302	Climate Change and Sustainability	3	45	
Practical	US-MLSC-P302	Practicals based on Climate Change and Sustainability	1	30	
Theory	US-MLSC-303	Environment Microbiology and Biotechnology	3	45	
Practical	US-MLSC-P303	Practicals based on Environment Microbiology and Biotechnology	1	30	

SEMESTER IV

Theory/ Practical	Paper Code	Course Title	No. of Credits	No. of Lectures	Total Credits
Theory	US-MLSC-401	Environment Management and Tools of Management	3	45	8+4 = 12 (Major)
Practical	US-MLSC-P401	Practicals based on Environment Management and Tools of Management	1	30	
Theory	US-MLSC-402	Alternative Energies	3	45	
Practical	US-MLSC-P402	Practicals based on Alternative Energies	1	30	
Theory	US-MLSC-403	CSR, ESG and Environment Compliance	3	45	
Practical	US-MLSC-P403	Practicals based on CSR, ESG and Environment Compliance	1	30	

Summary - Master's Second Year Semester III Internal and External Detailed Evaluation Scheme

Sr. No.	Subject Code	Subject Title	Periods Per Week					Credits	Internal		Total Marks
			Units	S. L	L	T	P		S.L.E		
1	**US-MLSC-301**	Environment and Pollution	3	20%	3			3	15	60	75
2	**US-MLSC-P301**	Practicals based on Environment and Pollution			0		6	1		25	25
3	**US-MLSC-302**	Climate Change and Sustainability	3	20%	3			3	15	60	75
4	**US-MLSC-P302**	Practicals based on Climate Change and Sustainability			0		6	1		25	25
5	**US-MLSC-303**	Environment Microbiology and Biotechnology	3	20%	3			3	15	60	75
6	**US-MLSC-P303**	Practicals based on Environment Microbiology and Biotechnology			0		6	1		25	25

Summary - Master's Second Year Semester IV Internal and External Detailed Evaluation Scheme

Sr. No.	Subject Code	Subject Title	Periods Per Week					Credits	Internal		Total Marks
			Units	S. L	L	T	P		S.L.E		
1	**US-MLSC-301**	Environment Management and Tools of Management	3	20%	3			3	15	60	75
2	**US-MLSC-P301**	Practicals based on Environment Management and Tools of Management			0		6	1		25	25
3	**US-MLSC-302**	Alternative Energies	3	20%	3			3	15	60	75
4	**US-MLSC-P302**	Practicals based on Alternative Energies			0		6	1		25	25
5	**US-MLSC-303**	CSR, ESG and Environment Compliance	3	20%	3			3	15	60	75
6	**US-MLSC-P303**	Practicals based on CSR, ESG and Environment Compliance			0		6	1		25	25

Course Outline
M.Sc. Part II: OUTLINE SEMESTER III

COURSE CODE	SEMESTER III	CREDIT	LECTURE
US-MLSC-301	**PAPER I – ENVIRONMENT AND POLLUTION**	**3**	**45**
UNIT I	Environment and Natural Resources	**1**	**15**
UNIT II	Environmental Pollution and Monitoring	**1**	**15**
UNIT III	Management of Solid waste	**1**	**15**
US-MLSC-P301	Practical based on Environment and Pollution	**1**	**30**
US-MLSC-302	**PAPER II – CLIMATE CHANGE AND SUSTAINABILIY**	**3**	**45**
UNIT I	Climate Change and Management	**1**	**15**
UNIT II	Sustainability	**1**	**15**
UNIT III	Sustainable Development	**1**	**15**
US-MLSC-P302	Practicals based on Climate Change and Sustainability	**1**	**30**
US-MLSC-303	**PAPER III - ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY**	**3**	**45**
UNIT I	Soil and Water Microbiology	**1**	**15**
UNIT II	Bioremediation of Environmental Pollutants	**1**	**15**
UNIT III	Fermentation	**1**	**15**
US-MLSC-P303	Practical based on Environmental Microbiology And Biotechnology	**1**	**30**

M.Sc. PART II: SEMESTER III – DETAILED SYLLABUS

PAPER I – ENVIRONMENT AND POLLUTION

Course code	Title	Lectures
US-MLSC-301	**ENVIRONMENT AND POLLUTION**	**45**
	UNIT I – Environment and Natural Resources **1.** Environment and Its Integral Components. **2.** Concept of Ecosystem: a. Ecosystem stability and factors affecting stability. b. Ecosystem services. c. Carrying Capacity of Ecosystems. **3.** Biodiversity and Natural Capital assessment. **4.** Biomimetics. **5.** Natural Resources: definition, Current Status and policies: a. Natural resources and their management - Water, Land, Forest, Energy, Minerals. b. Resource protection and management. c. Watershed Management: Definition, Concepts, principles, and classification in watershed management. Rainfall and runoff, Water balance approach, Water budgeting and auditing, Topographic surveying, Water conservation and harvesting methods – Importance and techniques, artificial recharge of groundwater. **6.** Eco restoration of Wasteland, Desertification and its control. **7.** Smart Agriculture. **8.** Case Studies of Land, Water, Forestry, Fishery/ Environment and Development Issues.	**15**
	Unit II: Environmental Pollution and Monitoring **1. Air Pollution Prevention & Control:** a. Criteria for air pollutants. Sampling and monitoring of air pollutants (gaseous and particulates); period, frequency and duration of sampling. Principles and instruments for measurements of (i) ambient air pollutants concentration and (ii) stack emissions. b. Particulate control equipment: Gravity settling chambers, cyclone separators, wet collectors, venturi scrubbers, fabric filters, absolute filters, High-Efficiency Particulate Air (HEPA) & Ultra Low Particulate Air (ULPA) Filters, electrostatic precipitators, collection efficiencies of various systems. c. Control of gaseous pollutants through adsorption, absorption, condensation and combustion including catalytic combustion. Control of Auto-exhaust emissions: Afterburners, Catalytic convertors. d. Control devices for particulate matter: Principle and working of: settling chamber, centrifugal collectors, wet collectors, fabric filters and electrostatic precipitator, Control of odour. **2. Water Pollution Prevention and Control:** a. Water Pollution and Prevention – Types, National Status, Need of Wastewater Treatment.	**15**

	b. Measurement of water quality parameters: sampling and analysis for pH, EC, turbidity, TDS, hardness, chlorides, salinity, DO, BOD, COD, nitrates, phosphates, sulfates, heavy metals and organic contaminants. Microbiological analysis – MPN. Indian standards for drinking water. c. Treatment Methods: o Preliminary and Primary treatment: Screening, grit removal, oil-water separation, equalization, and Neutralization, Sedimentation, Coagulation, Flocculation. o Secondary Treatment: Activated sludge process and its modifications: Aerobic, Facultative & Anaerobic, Attached growth, and suspended growth (waste stabilization ponds, lagoons, conventional and extended aeration process, bio-tower, RBCs) and advanced biological treatment methods (MBR, SBR), Handling, treatment, and disposal of sludge from wastewater treatment plant. o Tertiary and Advanced treatment concerning water renovation technologies and the concept of zero wastewater discharge. o Common effluent treatment plants.	
	Unit III: Management of Solid waste **1.** Solid Waste - types and sources. Solid waste characteristics, generation rates, solid waste components, proximate and ultimate analyses of solid wastes. **2.** Processing techniques and disposal of solid waste - Landfills, Landfill Gas Collection, Composting, Incineration, and Pyrolysis. **3.** Reduce, Recovery & Reuse - Conversion of waste products into Energy/ Items. **4.** Hazardous waste - Management issues: Definition, classification, and Generation of HW, HW Management and handling rules and regulatory processes. a. Leachate Management, packaging requirements under DOT regulations for safe transport of hazardous wastes. **5.** Use of environmentally sound technologies for treatment and disposal of HW. a. Treatment and disposal methods of HW. **6.** Biomedical Waste Management: Definition, sources, categories of Biomedical waste as per the legislation. Segregation, transportation, treatment and disposal methods. **7.** E waste & Battery Waste Management: Sources, effects, segregation, recycling treatment and disposal.	**15**

Course code	Title	Lectures
US-MLSC-P301	**Practicals based on Environment and Pollution**	**30**
	• Quality assessment of Soil and Water samples. • Determination of Heavy Metals and toxic effects on organisms. • Report on Visit to NGO/Biomedical Waste Management site/Hazardous Waste Management/Pollution Control facility.	

References

1. Principles of Instrumental Analysis by Skoog Douglas A.
2. Instrumental Methods Of Chemical Analysis by Chatwal & Anand
3. Air Pollution Vol. III.: Measuring, Monitoring & Surveillance of Air by Stern Arthur C.
4. Basic Concepts of Analytical Chemistry by Khopkar S. M.
5. Analytical Chemistry (E.D.8) by Gary D. Christian.
6. Fundamentals Of Analytical Chemistry – Skoog & Others
7. Modern Concepts of Ecology (E.D. 5) by Kumar H. D.
8. Ecology (ED. 2) by Odum Eugene P.
9. Global Biodiversity Assessment by Heywood V.H. & Watson, R.T.
10. Conservation biology: voices from the Tropics by Gibson, L. & Raven, P.HG.
11. Fundamentals Of Air Pollution by Stern Arthur C. & Others
12. Air Pollution Vol. IV.: Engineering Control Of Air Pollution (ED 3) by Stern Arthur C.
13. Environmental Pollution Control Engineering by Rao C.S.
14. Pollution Management. Vol I S.K. Agarwal
15. Pollution Management. Vol II by S.K. Agarwal
16. Wastewater Engineering Treatment, Disposal, Reuse by Metcalf & Eddy Inc.
17. Waste Water Treatment: Rational Methods of Design & Industrial By NarayanaRao M. & Data Amol K.
18. Principles Of Environmental Engineering by Jorgensen S.E.
19. Waste Water Treatment for Pollution Control by Soli J Arceivala
20. Chemical and Biological Methods for Water Pollution Studies by Trivedi R.K. & Goel P.K.
21. Environmental Engineering by Hardward S Peavy & Others
22. Solid Waste Management - A Manual by All India Institute of Local Self-Government Publications
23. Toxic and Hazardous Waste by Sinha P.C.
24. Manual on Solid Waste Management by Palnitkar, Sneha
25. Basic Hazardous Waste Management by William C. Blackman
26. Management of Municipal Solid Waste by Ramchandra T. V.
27. Solid Waste Management by H V. Bijlani

PAPER II – CLIMATE CHANGE & SUSTAINABILITY

Course code	Title	Lectures
US-MLSC-302	**CLIMATE CHANGE & SUSTAINABILITY**	**45**
	UNIT I- Climate Change and Management **1. Climate Change and its Management:** a. Causes and Impact of Climate Change. b. Historical Perspectives in Climate Change Management - Earth Summit, Kyoto Protocol (CDM, Joint Implementation and Emission Trading), Bali Agreement (RED, RED+), Durban Platform. c. Climate Justice, Paris Agreement, NDCs Green House Gas Accounting and Carbon Credit. d. Climate Modelling, Climate Risk Assessment. Science Based Targets Internal. e. Carbon Pricing. f. National Action Plan for Climate change (NAPCC). **2. Green Transitions** a. Carbon Management, Pollution abatement and testing.	**15**

	b. Reduction in Carbon/ CHG Emissions, Resource efficiency, Renewable Energy Intensity. c. Decarbonisation, Carbon footprint, Carbon offsets, Means of Decarbonisation. d. Carbon removal methods.	
	UNIT II – Sustainability **1. Introduction to Sustainability:** a. Introduction to sustainability & its factors. b. Requirements for sustainability: food security and agriculture, renewable resources - water and energy, non-renewable resources, factors and trade-offs, sustainability conflicts, a conceptual framework for linking sustainability and sustainable development. c. Ecological Footprint, Fundamentals of ecology - types of ecosystems & interrelationships, factors influencing sustainability of ecosystems, ecosystem restoration - developmental needs. Principles of Sustainable Development. **2. Frameworks of Sustainability**: a. Analytical frameworks in sustainability studies, sustainability metrics: criteria and indicators. b. The significance of quantitative and qualitative assessments of sustainability; current metrics and limitations; metrics for mapping and measuring sustainable development. c. Application of the metrics in real scenarios.	**15**
	UNIT III – Sustainable Development **1. Introduction to Sustainable Development**: a. Glimpse into History and Current practices - Broad introduction to SD - its importance, need, impact and implications; evolution of SD perspectives (MDGs AND SDGs) over the years b. 1987 Brundtland Commission and outcome; UN summits (Rio summit, etc.) and outcome. **2. Dimensions to Sustainable Development**: a. Sustainable development in society, environment, culture and economy. b. Current challenges - natural, political, socio-economic imbalance. c. Sustainable development initiatives and policies of various countries: global, regional, national, local. d. Needs of present and future generation - Political, economic, and environmental aspects. e. Gauging Sustainable Development - Sustainability and development indicators and SDGs. **3. Strategies in Promoting Sustainable Development** **4. Sustainable Urban Development:** a. Green City Challenges and Green City Solutions. b. Urban Farming. c. Rural and Urban Planning.	**15**

Course code	Title	Lectures
US-MLSC-P302	**Practicals based on Climate Change and Sustainability**	**30**
	• Use of GIS for mapping Topography and Biodiversity of Habitat. • Design environmental CSR projects focusing on areas such as waste management, energy efficiency, and biodiversity conservation, and evaluate their effectiveness in addressing environmental challenges and enhancing corporate reputation. • Impact assessment of Anthropogenic activities in eco-tourism spots of different regions, examining their contribution to local economies, community development, and biodiversity conservation. • Conduct a triple bottom line assessment of businesses operating in the food, water, and energy sectors, evaluating their economic, social, and environmental performance and impacts on sustainability.	

Reference

1. The Sustainability Revolution: Portrait of a Paradigm Shift by Edwards, Andres R., New Society Publishers, 2005.
2. Sustainable development in India: Stocktaking in the run up to Rio+20: Report prepared by TERI for MoEF, 2011.
3. Report of the Department for Policy Coordination and Sustainable Development (DPCSD), United Nations Division for Sustainable Development.
4. Corporate Social Responsibility Part I, Part II, Part III by David Crowther and Guler Aras.
5. Conventional and Non-conventional Energy sources G. D Rai.
6. Renewable Energy Programmes in India: some recent developments, Sinha P.C.
7. Renewable Energy Resources: Basic Principles And Applications Tiwari, G.N., Narosa Publishing House.

PAPER III - ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY

Course code	Title	Lectures
US-MLSC-303	**ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY**	**45**
	Unit I: Soil and Water Microbiology **1. Water Microbiology:** a. Microbiology of water: aquatic ecosystems-types- freshwater (ponds, lakes, streams) - marine (estuaries, mangroves, deep sea, hydrothermal vent, saltpans, coral reefs). b. Zonation of water ecosystems. c. Self-purification of water. d. Assessment of microbial quality of water, characteristics of pollution indicator microorganisms and polluted water. e. Fresh water quality standard, purification of water for human use, waste water disposal, and reclamation. f. Brief account of major waterborne diseases and their control measures. **2. Soil Microbiology:** a. Microflora of various soil types, rhizosphere and phyllosphere. b. A brief account of microbial interactions and plants in soil, Role of microorganisms in soil fertility, and concepts of chemoorganotroph and chemolithotroph. c. Biological N_2 fixing organisms, symbiotic fungi, Phosphate solubilizing organisms. d. Ecology of litter decomposition and extracellular enzymes.	**15**
	Unit II: Bioremediation of Environmental Pollutants **1.** Concept of Bioindicators. **2.** Introduction to Biofertilizers, Biofuels and Biosensors. **3.** Bioremediation – Definition, types and role of plants and microbes for in situ and ex situ bioremediation: a. Bioremediation of Heavy Metals. b. Acclimatization, microbial bioremediation and biodegradation of pesticides, hydrocarbons, detergents & oil. c. Use of microbes (bacteria and fungi) and plants in Biotransformation. d. Phytoremediation: Waste water treatment using aquatic plants; Root zone treatment. e. Microbial enhanced oil recovery, bioleaching of copper, gold and uranium.	**15**
	Unit III: Fermentation 1. Industrial fermentation: Primary and secondary metabolites, Microbial growth kinetics, Basic functions of fermenter. 2. Design and components of Bioreactor, types of Bioreactors: Batch and Continuous, microbial, algal, animal cell, Submerged and Solid-State bioreactor. 3. Fermentation- Scale up, Biosensors, and Downstream processing. 4. Bioreactors for wastewater treatments: Reactors types and design, Reactors in series,	**15**

	Development, and optimization of membrane bioreactor process for sanitary and industrial sewage treatment. 5. Industrial production of microbial biomass: Antibiotics, Enzyme and Alcohol.	

Course code	Title	Lectures
US-MLSC-303	**Practicals based on Environmental Microbiology and Biotechnology**	**30**
	• Study of Microflora from Soil, Air and Water samples. • Use of Microflora for setting up of Microcosms for Bioremediation.	

References

1. Microbiology by Pelczar Michael J. & Others
2. General Microbiology by Stanier Roger Y. & Others
3. Fundamentals Of Microbiology by Frobisher Martin & Others
4. Microbiology for Environment and Public by R M. Sterritt & J N. Lester
5. Bioremediation by Baker, K H., and Herson, D.S.
6. Bioremediation technology recent advances M.H.Fulekar
7. Metcaff & Eddy Inc, (2002). Wastewater engineering: Treatment and Reuse, 4th edition, McGraw Hill higher education. (ISBN; 9780070495395)
8. Doble, M. & Anil kumar. (2005). Biotreatment of industrial effluents. Butterworth Heinemannan imprint of Elsevier. (ISBN; 9780080456218)
9. EL-Mansi E.M.T. and Bryce C.F.A. Fermentation Microbiology and Biotechnology, Taylor & Francis.
10. Alberghina Lilia. Protein Engineering in Industrial Biotechnology. Harwood Academic Publishers.
11. Jogdand S. N. Gene Biotechnology. Himalaya Publishing House.
12. Prescott & Dunn's. Industrial Microbiology. 4th ed, CBS publishers & Distributors.
13. A.H. Patel. Industrial Microbiology.

SEMESTER IV
Course Outline

M.Sc. Part II: OUTLINE SEMESTER IV

COURSE CODE	SEMESTER IV	CREDIT	LECTURE
US-MLSC-401	**PAPER I – ENVIRONMENTAL MANAGEMENT AND TOOLS OF MANAGEMENT**	**3**	**45**
UNIT I	Environmental Management	**1**	**15**
UNIT II	Environmental Auditing and Tools	**1**	**15**
UNIT III	Environmental Valuation and Ecotourism	**1**	**15**
US-MLSC-P401	Practicals based on Advances in Sustainable Development	**1**	**30**
US-MLSC-402	**PAPER II - ALTERNATIVE ENERGIES**	**3**	**45**
UNIT I	Wind, Solar and Hydro Energy	**1**	**15**
UNIT II	Biofuels and Hydrogen Based Energy	**1**	**15**
UNIT III	Energy Planning for Renewable Energy Systems	**1**	**15**
US-MLSC-P402	Practicals based on Renewable Energy Technology	**1**	**30**
US-MLSC-403	**PAPER III - CSR, ESG AND ENVIRONMENTAL COMPLIANCE**	**3**	**45**
UNIT I	CSR, ESG and Reporting	**1**	**15**
UNIT II	Environmental Compliance and Regulations	**1**	**15**
UNIT III	Advanced Sustainable Development	**1**	**15**
US-MLSC-P403	Practicals based on Environmental Compliance and Requirements	**1**	**30**

M.Sc. PART II: SEMESTER IV DETAILED SYLLABUS

PAPER I – ENVIRONMENTAL MANAGEMENT AND TOOLS OF MANAGEMENT

Course code	Title	Lectures
US-MLSC-401	**ENVIRONMENTAL MANAGEMENT AND TOOLS OF MANAGEMENT**	**45**
	UNIT I - Environmental Management **1. Environment Management:** a. Principles of Environment Management. b. Environmental management concept, importance of environment management, Environment management tools, emerging environment management strategies. c. Actions for environmental protection: National and international initiatives. d. Agreements and Treaties: Stockholm Conference 1972, Rio Earth Summit 1992 and current developments. e. Protocol on Ozone Depleting Substances. f. Prominent NGOs and their contributions. **2. Environment Management Systems:** a. Need for EMS Standards. Planning and Implementation of EMS. b. Evolution of ISO 14000 Series Standards. ISO 14000 Series Architecture. ISO 14001: EMS Specification Standards. c. Conforming to ISO 14001: Guidelines. Benefits of Implementation of ISO 14001. d. BIS adoption of ISO 14000 series. ISO 9000 Standards. e. Evolution of ISO 450003.	**15**
	UNIT II - Environmental Auditing and Tools **1. Environmental Auditing:** a. Evolution of and code of practice for environmental audit. b. Types of environmental audits: Objectives-based and client-driven types. c. Waste audits and pollution prevention assessments. d. Liability audits and sites assessment. e. General audit methodology and audit process: Introduction, the basic structure of an environmental audit program: General steps in an environmental audit procedure. f. Overview of elements of audit processes: audit protocols (why, who, what and how). g. Audit certification and authorization. h. Process and product bench marks as part of QA/QC in audit. **2. Environmental Impact Assessment:** a. Concept of EIA, its scope, EIA study procedures, requirements for the same. Resources needed for EIA. b. Report preparation. c. Legal aspects- Environmental Clearance Procedure in India	**15**
	Unit III - Environmental Valuation and Ecotourism **1. Environmental Valuation:**	**15**

	a. Market Failures in environmental issues and natural resources. b. Values (Economic or otherwise) of Environment and Natural Resources: Use, Option, Existence: i. Signals of Natural Resource Depletion/ Scarcity and valuation methods such as Environmental Health Costs, Amenities and Hedonic Pricing, Travel Cost methods, Contingent Valuation Methods, Choice Experiments, ii. Limitations of these signals. iii. Payment for Ecosystem Services (PES). c. Environmental Risk Management & Environmental Strategy. d. Environmental and Ecological Stewardship. **2. Ecotourism:** a. Introduction to Ecotourism History and scope of ecotourism; Components of ecotourism. b. Ecotourism planning: Site diagnostics, Target groups; Ecotourism industry and its stakeholders. c. Commercialization of ecotourism. d. Types of Ecotourism. e. Ecotourism management plans and Ecotourism resources in India. f. Community participation in ecotourism. g. Role of NGOs; Ethical and legal aspects; Ecotravel and environmental awareness. h. Impacts of ecotourism, Green report card, Eco-labelling; Environmental sustainability practices.	

Course code	Title	Lectures
US-MLSC-P401	**Practicals based on Environmental Management and Tools of Management**	**30**
	• Estimate the health costs associated with environmental pollution by quantifying the impacts of pollutants on human health and healthcare expenditures. • Conduct an environmental audit of a local organization or facility to assess compliance with environmental regulations and standards, and propose recommendations for improvement. • Demonstrate environmentally sound waste management techniques, such as recycling, composting, and waste-to-energy conversion, through practical exercises or field trips. • Plan City farming - Visit urban agriculture initiatives, such as rooftop gardens or community farms, to learn about sustainable food production practices and their role in urban ecosystems.	

References

1. Environmental Impact Analysis by Jain R.K. & Others
2. Pollution Management in Industries by Trivedi R. K.
3. Environmental Impact Assessment by Canter Larry W.
4. Environmental Auditing by A.K. Srivastava
5. Handbook Of Environmental Laws, Acts Guidelines, Compliances & Standards Vol-I & VII by R.K. Trivedi
6. Sustainable Urbanism: Urban Design with Nature by Douglas Farr
7. The Routledge Handbook of Urban Resilience" edited by Michael A. Burayidi
8. The Sustainable City by Steven Cohen
9. Green Cities of Europe: Global Lessons on Green Urbanism by Timothy Beatley
10. Sustainable Urban Development Reader edited by Stephen M. Wheeler and Timothy Beatley
11. The Green Building Revolution by Jerry Yudelson

12. Urban Agriculture: Policy, Law, Strategy, and Implementation edited by Henk de Zeeuw and Pay Drechsel
13. Rainwater Harvesting for Drylands and Beyond by Brad Lancaster
14. The Sustainable Lifestyle by Emily Anderson
15. Environmental and Natural Resource Economic by Tom Tietenberg and Lynne Lewis
16. Valuing Environmental Preferences: Theory and Practice of the Contingent Valuation Method in the US, EU, and Developing Countries by Ian J. Bateman et al.
17. Environmental Economics: An Introduction by Barry C. Field and Martha K. Field
18. The Economics of Climate Change: Adaptations Past and Present by Gary D. Libecap and Richard H. Steckel
19. Corporate Social Responsibility: Strategy, Communication, Governance by Andreas Rasche and Mette Morsing
20. Environmental Valuation: A Worldwide Compendium of Case Studies edited by Timothy C. Haab and Kenneth E. McConnell

PAPER II - ALTERNATIVE ENERGIES

Course code	Title	Lectures
US-MLSC-402	**ALTERNATIVE ENERGIES**	**45**
	UNIT I - Wind, Solar and Hydro Energy 1. **Wind energy:** Wind energy resources, Power in wind, Wind Turbine design considerations, Grid connected wind farms, Hybrid power systems, and Economics of wind power systems, economic analysis methods, and wind energy conversion system. 2. **Solar energy:** Introduction, Earth's orbit, Solar constant and Solar spectra, Solar angles, Collector angles, Solar irradiance, Photovoltaic energy conversion, types of Photovoltaic systems; Solar thermal electric power plant - Solar thermal systems, environmental impact. 3. **Nuclear energy**: Fission and fusion, Nuclear fuel, Nuclear reactor – principles and types. 4. **Hydro energy systems:** Marine energy, understanding the power of marine energy, global development of Marine energy, Ocean wave energy, Ocean tide energy, Mathematical modeling of Tidal schemes, Global environmental impact; low power hydro plants, Micro Hydro plants**.**	**15**
	UNIT II - Biofuels and Hydrogen Based Energy 1. **Biofuels:** a. Biomass as a source energy, types of biomass, energy content of biomass, harvesting methods of biomass, conversion of biomass, thermos-chemical conversion of biomass, biodiesel production, bioethanol production, forest biomass production, forest species, environmental impact resulting from the generation and exploitation of forest biomass. 2. **Hydrogen Based Energy: HFC** a. Introduction to hydrogen economy: production, storage, and transportation systems. b. Fuel cells: Concept, key components, physical and chemical phenomena, advantages and disadvantages, different types, and applications. c. Fuel cell design and performance: Fuel cell technology, thermodynamics and	**15**

	electrochemical kinetics, fuel cells for automotive applications, and fuel cell components.	
	UNIT III - Energy planning for renewable energy systems **1.** Modern power electronic technology for renewable energy sources. **2.** Future trends in wind-power technology. **3.** Power electronics in photovoltaic systems. **4.** Recent trends in energy storage technologies. **5.** Power quality instrumentation. **6.** Regulatory framework. **7.** Energy resource allocation. **8.** Region-dependent development in energy planning.	**15**

Course code	Title	Lectures
US-MLSC-P402	**Practicals based on Alternative Energies**	**30**
	• Calculate and compare the carbon footprint (CCF) and ecological footprint (CEF) of different products, services, or organizations, using standardized methodologies and tools. • Design a Net zero plan for the laboratory using Alternative Energy Resources. • Development of Green Campus.	

Reference

1. Buchla, DM, Kissell TE and Floyd TL, 2017, Renewable Energy Systems, Pearson Education.
2. Zobaa, AF and Bansal, RC, 2011 Handbook of Renewable Energy Technology, World Scientific Publishing Co. Pte. Ltd. Singapore.
3. Boyle, 2012, Renewable Energy: Power for a Sustainable Future, Oxford University Press, 3rd Edition
4. Renewables 2005: Global Status Report: Notes and References Companion Document, REN21 Network Report, 2005
5. Khan, 2017, Non-Conventional Energy Resources, McGraw Hill Education, India Pvt Ltd.

PAPER III - CSR, ESG AND ENVIRONMENTAL COMPLIANCE

Course code	Title	Lectures
US-MLSC-403	**CSR, ESG AND ENVIRONMENTAL COMPLIANCE**	**45**
	UNIT I – CSR, ESG and Reporting **1. CSR and ESG:** a. Introduction of CSR & ESG. b. Evolution of CSR. c. Triple Bottom Line (TBL). d. International framework for Corporate Social Responsibility. e. CSR notification (MOEFCC and amendment to Company Act), CEPI ESG Sustainability Reporting Frameworks and Guidelines (GRI Standards, CDP, SASB, TCFD). f. Business Responsibility Sustainability Reporting (BRSR). g. Impact Reporting. h. Integrated Reporting. i. Dow Jones Sustainability Index (DJSI) and its principles. **2. Objectives and Importance of Environmental, socioeconomic, and Governance Areas Covered under ESG Principles:** a. Science Based Net Zero Targets (SBTi). b. Interim Targets and Transition Plans. c. High Priority Issues and Impact Areas. d. Awareness on environment protection, energy conservation and management. **3. Risk management:** Concept of Risk, Types of Risk, Risk Assessment and Mitigation.	**15**
	UNIT II – Environmental Compliance and Regulations **1.** Historical Perspectives of Environmental Regulations in India. **2.** Process of enactment of compliance in India, Environmental Policy of India. **3.** Wildlife (Protection) Act, 1972 (WPA). **4.** Water (Prevention and Control of Pollution) Act, 1974 & rules including CTO, CTE. **5.** Air (Prevention and Control of Pollution) Act, 1981 & rules Environment (Protection) Act. 1986. **6.** Biodiversity Act, 2002: salient features and regulation, National Green Tribunal Act, 2010. **7.** EPA Rules, Including Environmental Statement, Categories of Industries, Eco sensitive Zone notifications Noise Pollution, CRZ notifications. **8.** Forest Act 1987. **9.** The Factories Act, 1948. **10.** Public Liability Insurance Act, 1991. **11.** Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989. **12.** International Laws: a. The Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer and the Ozone Depleting Substances (Regulation and Control) Rules, 2000.	**15**

	b. Basel Convention on the control of trans boundary movement. c. Framework Convention on Climate Change (UNFCCC), New York, 19ZX92, including the Kyoto Protocol, 1997 and with the latest amendments. d. Coastal Regulation Zone notification.	
	UNIT III – Advanced Sustainable development **1.** Sustainable Infrastructure and Industrialization. **2.** Sustainable Cities - Urbanisation and its impact of growth on Water, Energy, Non-motorised and motorized transport, Waste generation. **3.** Sustainable Transport. **4.** Green Building Concept: a. Indian Green Building Council (IGBC). b. Green Rating for Integrated Habitat Assessment (GRIHA). c. Leadership in Energy and Environmental Design (LEED). d. Excellence in Design for Greater Efficiencies (EDGE). e. Sustainable Energy/Energy Sustainability (BEE). **5.** Life Cycle Assessment- Evolution of Life Cycle Assessment (LCA). Different application of LCA. **6.** Procedure for LCA: Defining goal and scope, preparation of Life Cycle Inventory, assessment of environmental impact, and evaluation of environmental profiles. Stage in LCA of a process/product. Profile. Cradle to grave approach. **7.** Software for Performance of Life Cycle. **8.** Assessments. Environmental Effects to be considered in LCA. **9.** Comprehensive Sustainable Development Plan (CSDP) - Case studies. **10.** Eco label. **11.** Current Issues in implementation of Sustainable Development initiatives. **12.** Role of NGOs in Sustainable Development, NGO – Government Relations.	**15**

Course code	Title	Lectures
US-MLSC-P403	**Practicals based on CSR, ESG and Environmental Compliance**	**30**
	• Conceptualisation of Life Cycle Assessment of a product. • Prepare an Environment Impact Assessment report of one development project. • Develop a CSR report for a company or organization following the Global Reporting Initiative (GRI) Standards, including disclosures on environmental, social, and governance (ESG) performance indicators and analysis of Investor's approach for investment decisions. • Use online tools or software to simulate the effects of different policies and measures aimed at reducing carbon emissions, and analyze their potential impact on climate change mitigation efforts. • Understanding Lawsuits for Environmental Issues: Procedure of filing a case.	

Reference

1. Legal Aspects of Environmental Pollution and Management, S.M.Ali, 1992
2. Environmental Protection and Laws, Jadhav and Bhosale, V.M.
3. Environmental Policy in India, Shekhar Singh
4. Declaration of :The Stockholm Conference,Rio, Rio+5 and Ri +10
5. Our Common Future, WECD,1991
6. Environmental Law and Policy of India ,Diwan,S. And Rosencranz, A

Course Code	DISSERTATION AND PLACEMENT GROOMING	Credits

Overview of the Syllabus

To inculcate the knowledge base on sustainable development with a view to balance our economic, environmental and social needs, allowing prosperity for now and future generations. To train students to undertake major initiatives in the efficient management of natural resources and the prevention of environmental pollution with focus on Sustainable Development. To equip individuals to solve problems of environmental pollution and environmental degradation through before end of pipe (BEOP) interventions, over and above the use of conventional way of end-of-pipe (EOP) interventions. To promote understanding of efforts that can be made at the Industry and Government level to improve the environment, the economy and the quality of life of biotic and abiotic communities. To use environmental management tools that help to improve the quality of the environment, to assess local vulnerabilities with respect to climate, natural disasters and to achieve sustainable developmental needs.

Career opportunities

- Every industry sector (such as automobile, food processing, chemical, pharmaceutical, power including renewable energy, Textile, fertilizer, Cement, Infrastructure, Steel, refinery, tyre, etc.)
- Pollution control boards, local bodies including municipal corporations
- Environmental Consultancy firms
- NGO's, Banks (study environmental feasibility of environmental projects)
- Research and development laboratory
- Multi star hotels (manage wastewater treatment facilities, Environmental management systems)
- Hospitals (Environmental Quality control, Hospital waste management)
- Waste management industries
- Certifying /Audit agencies