Kurukshetra University, Kurukshetra
Institute of Environmental Studies

M. Tech.
(Energy & Environmental Management)

Scheme and Syllabus
(Based on CBCS-LOCF Pattern)
(Effective from 2020-21 in phased manner)

Faculty of Life Science, KUK
(August, 2020)

VISION AND MISSION OF THE INSTITUTE

To contribute to environmental sustainability and wise use of natural resources for the benefit of society through education, research, outreach and networking on the environment.

Programme Outcomes (POs) for PG courses of Faculty of Life Sciences

The PG Courses of Faculty of Life Sciences will be able:

PO1 To acquaint students with recent knowledge and techniques in basic and applied biological sciences.

PO2 To develop understanding of organismal, cellular, biochemical and environmental basis of life.

PO3 To provide insight in to ethical implications of biological research for environmental protection and good laboratory practices and biosafety.

PO4 To develop problem solving innovative thinking with robust communication and writing skills in youth with reference to biological, environmental and nutritional sciences.

PO5 To understand application of biotic material in health, medicine, food security for human well being and sustainable development.

PO6 To impart practical and project based vocational training for preparing youth for a career in research and entrepreneurship in fields of life sciences for self reliance.

Programme Specific Outcomes of M.Tech. (Energy and Environmental Management)

PSO1 To develop professional skills in students on conservation of energy, new energy resources and environmental management with the use of sustainable techniques.

PSO2 To provide knowledge on renewable and alternate energy resources.

PSO3 To provide knowledge on energy and environment system analysis.

PSO4 To create awareness on sustainable technologies in changing climatic scenarios.

PSO5 To educate students on tools, and modern techniques of energy efficiency and conservation.

PSO6 To provide job-oriented skills with training, seminar and projects.

KURUSKHETRA UNIVERSITY, KURUKSHETRA
INSTITUTE OF ENVIRONMENTAL STUDIES
SCHEME OF EXAMINATION FOR
M.Tech. Energy and Environmental Management (EEM)

FIRST SEMESTER

Paper Code	Title of Paper	Type of Paper	Hours/Week	Credits	Marks		
					Internal Assessment	Final Examination	Total
MEMT-101	Ecology and Systems Analysis	Core	4	4	40	60	100
MEMT-102	Energy Resources and Management	Core	4	4	40	60	100
MEMT-103	Energy and Climate Change	Core	4	4	40	60	100
MEMT-104	Research Techniques and Quantitative Methods	Core	4	4	40	60	100
MEMT-105	Practical - I	Core	8	4	40	60	100
MEMT-106	Practical - II	Core	8	4	40	60	100
Total				24	240	360	600

Note: Each Theory Final Examination will be of 3 hours and practical examination will be of 6 hours duration.

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SCHEME OF EXAMINATION FOR
M.Tech. Energy and Environmental Management (EEM)

SECOND SEMESTER

Paper Code	Title of Paper	Type of Paper	Hours/Week	Credits	Marks		
					Internal Assessment	Final Examination	Total
MEMT-201	Environmental Assessment and Management	Core	4	4	40	60	100
MEMT-202	Renewable Energy and Technology	Core	4	4	40	60	100
MEMT-203	Environmental Remote Sensing & GIS	Core	4	4	40	60	100
MEMT-204	Environmental Biotechnology and Biofuels	Core	4	4	40	60	100
MEMT-205	Seminar	Core	1	1	25	-	25
MEMT-206	Practical - I	Core	8	4	40	60	100
MEMT-207	Practical - II	Core	8	4	40	60	100
Total				25	265	360	625

Note: Each Theory Final Examination will be of 3 hours and practical examination will be of 6 hours duration.

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M.Tech. Energy and Environmental Management (EEM)

THIRD SEMESTER

Paper Code	Title of Paper	Type of Paper	Hours/ Week	Credits	Marks		
					Internal Assessment	Final Examination	Total
MEMT-301	EL-1A (Energy Conservation and Efficient Systems)	Elective	4	4	40	60	100
	EL-1B (Environmental Bioremediation Technology)						
	EL-1C (Environmental Policies, Laws and Impact Assessment)						
MEMT-302	EL-2A (Industrial Energy)	Elective	4	4	40	60	100
	EL-2B (Energy from Waste)						
	EL-2C (Environmental Modelling)						
MEMT-303	Minor Project/Practical	Core	8	4	40	60	100
MEMT-304	Summer training (Report and Seminar)	Core	-	2	50	-	50
MEMT-305	Seminar	Core	1	1	25	-	25
MEMT-306	Practical	Elective	8	4	40	60	100
Total				19	235	240	475

Note: The minor project in the form of summer training (8 weeks) report with some Industry/NGO/Research Institute/ organization will be submitted by the student in the 3rd Semester and the student will give a presentation on the training.

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M.Tech. Energy and Environmental Management (EEM)

FOURTH SEMESTER

Paper Code	Title of Paper	Type of Paper	Credits	Marks		
				Internal Assessment	Final Examination	Total
MEMT-401	Dissertation	Core	10	-	250	250
MEMT-402	Seminar on Dissertation	Core	2	50	-	50
MEMT-403	Viva-voce on Dissertation	Core	2	-	50	50
MEMT-404	Progressive Seminar/ Laboratory Development Work	Core	2	50	-	50
Total			16	100	300	400

Note: M.Tech Dissertation will be evaluated by the Internal Supervisor/ Examiner and an External Examiner.

The Dissertation will be based on scientific data collection, analysis and fieldwork.

ECOLOGY AND SYSTEMS ANALYSIS
MEMT-101

Max. Marks: 60 + 40
Total Credits: 4
Time: 3 Hours

Objectives:
The aim of this course is to make students understand the basic concept of ecology, ecosystem, biological diversity, biomes and biogeochemical cycles, ecosystem disturbances, energy flow and population dynamics. The students will be able to apply concepts of ecology in better understanding of energy and environment and to understand different biotic interactions and ecological modelling.

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

- **CO1** Understand the concepts of ecology, population, community and ecosystems interactions.
- **CO2** Gain knowledge about concept of sustainable development
- **CO3** Explain the disturbances in natural environment and their mitigation measures
- **CO4** Understand cycling of nutrients and energy flow (energy transfer and transformation) in ecosystem.
- **CO5** Understand the concept, methodology and basic tools of environmental modeling
- **CO6** Become aware of different modeling approaches, their scope, limitations and applications
- **CO7** Gain knowledge about different analytical models and their applications in ecological studies

Note:-
For final theory exam, time allotted will be of 3 hours and nine questions will be set. Question No.1 (objective/short answer type) covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each Unit. The candidates will be required to attempt Q.No.1 and any four, selecting one question from each unit. All the questions will carry equal marks.

Unit-I

Introduction : Aims and scope of ecology, biological levels of organization-genes to biosphere, Sustainable development, Ecological sustainability, Ecological footprint, Living planet Index, Human dimensions in ecology
Population ecology: Population and metapopulation, Population growth and regulation, Biotic interactions: Competition, mutualism, parasitism, predator-prey relations.

Unit-II

Community structure and organization: Nature of community and continuum, Ecological niche, Keystone species, Biological diversity, Ecosystem disturbance and succession. Biome and aquatic systems: Distribution, characteristics, climate and biota. Natural and anthropogenic disturbances, Invasive species: Ecology, impacts and control.

Unit-III

Ecosystem components, Ecosystem processes-photosynthesis and decomposition, Global C and N cycle, Man's impact on nutrient cycles. Energy in biological systems: Biological energy transformations, global distribution of primary productivity, human appropriation of productivity, energy flow models of terrestrial and aquatic systems.

Unit-IV

Concept of ecosystem modeling, Ecosystem stability, Cybernetics and ecosystem regulation.Systems theory, Ecological models: Compartment model, matrix model, statistical model, Mathematical model, Energy-Circuit Analog Model. Analytical models in Ecology: logistic model of population growth, Lotka-Volterra model, Models of succession.

Suggested Reading:

1. Begon, M., Harper, J.L. and Townsend, C.R. 1986. *Ecology: Individuals, Populationsand Communities*. Blackwell, Oxford.
2. Chapin, F.S., Matson, P.A. and Mooney, H.A. 2002. *Principles of Terrestrial EcosystemEcology*. Springer-Verlag, New York.
3. Odum, E.P. 1983. *Basic Ecology*, Sanders, Philadelphia.
4. Singh K.P. and. Singh J.S. 1992. Tropical Ecosystems: Ecology and Management. WileyEastern Limited, Lucknow, India.
5. Singh, J.S., Singh S.P. and Gupta S.R. 2015. *Ecology, Environmental Science andConservation*, S.Chand Publishers, New Delhi.

Teaching-Learning Process

- **Lectures:** Supported by black board teaching, power point presentations, related videos and demonstrations
- **Assignments and exercises**
- **Test:** Knowledge of the students is tested through surprise tests, quiz and sessional tests.

CO-PO MAPPING for MEMT 101

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
C101.1	3	2	1	2	2	2
C101.2	2	2	2	2	3	3
C101.3	1	2	-	2	1	3
C101.4	2	3	1	2	2	2
C101.5	2	2	1	2	2	3
C101.6	2	2	2	2	2	2
C101.7	3	3	2	2	3	3
Average	2.14	2.29	1.5	2	2.14	2.57

CO-PSO MAPPING for MEMT 101

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
C101.1	1	-	1	1	-	-
C101.2	2	2	2	3	2	1
C101.3	1	-	1	2	-	-
C101.4	-	-	1	-	-	-
C101.5	-	-	3	-	3	1
C101.6	-	1	2	-	3	2
C101.7	2	2	3	1	3	2
Average	1.5	1.7	1.86	1.75	2.75	1.5

ENERGY RESOURCES AND MANAGEMENT
MEMT- 102

Max. Marks: 60+40
Total Credits- 04
Time: 3 Hours

Objectives:
The course provides students an overview of the basic concepts of energy, non-renewable and renewable energy resources and different management strategies. The students will be able to learn the need of management of energy resources and promotion of use of appropriate management technology in harnessing energy resources.

Outcomes: On successful completion of this course, the students will be able to**:**
CO1 Explain the concepts of thermodynamics and earth's energy budget
CO2 Categorize various types of energy resources
CO3 Explain origin and development of fossil fuels and their impacts on environment
CO4 Describe present scenario of solar, wind, tidal, geothermal and bioenergy in India
CO5 Describe management of various energy sources
CO6 Understands OPEC market behaviour and new energy polices in India.

Note:-
For final theory exam, time allotted will be of 3 hours and nine questions will be set. Question No.1 (objective/short answer type) covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each Unit. The candidates will be required to attempt Q.No.1 and any four, selecting one question from each unit. All the questions will carry equal marks.

Unit-I

Basic concepts of energy: Theoretical treatment of energy, Laws of thermodynamics, CarnotEfficiency, Energy quality. Energy balance of earth: Sunlight electromagnetic spectrum, Major flows in global hydrological cycle, Ocean-Currents and heat flux, Atmospheric circulation, Earth's energy budget

Unit-II

Energy resources: Non-renewable energy resources, Fossil fuels - origin and development of coal, types of coal and it reserves, coal - fired power plants - cleaner coal combustion - origin and reserves of petroleum and natural gas - composition and classification of petroleum - petroleum refining, Natural Gas origin, composition and storage. Environmental problems associated with petroleum.

Unit-III

Renewable energy resources: New developing renewable energy sources - nuclear fission reactors – fission and fusion power and the environment. Energy management and its present scenario in India- solar, wind, tidal, geothermal and bioenergy.

Unit-IV

Importance of management of energy sources, management of fossil fuel sources, oil crisis and economic development, OPEC Market behaviour, management of oil and natural gas-extraction and processing. New energy polices in India.

Suggested Readings:

1. Barrow, C. J. 2005. *Environmental Management and Development*. Taylor and FrancisGroup, London, New York.
2. Cleveland, C. J. 2008. *Encyclopedia of Energy*, Elsevier, New Delhi.
3. Kothari, D.P., Singal, K.C. and Ranjan, R. 2008. *Renewable energy sources and Emerging technologies*, Prentice hall, New Delhi.
4. Miller, G.T. 1997. *Environmental Science: Working With the Earth*, Wadsworth Publishing Company, Belmont, California.
6. Singh, J.S., Singh S.P. and Gupta S.R. 2015. *Ecology, Environmental Science andConservation*, S.Chand Publishers, New Delhi.

Teaching-Learning Process

- **Lectures:** Supported by black board teaching, power point presentations, related videos and demonstrations
- **Assignments and exercises**
- **Test:** Knowledge of the students is tested through surprise tests, quiz and sessional tests.

CO-PO MAPPING for MEMT 102

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
C102.1	2	2	-	2	1	1
C102.2	1	1	-	2	-	2
C102.3	2	2	-	2	-	1
C102.4	1	-	-	3	-	3
C102.5	-	-	-	3	2	3
C102.6	-	-	-	2	-	3
Average	1.5	1.67	-	2.33	1.5	2.17

CO-PSO MAPPING for MEMT 102

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
C102.1	1	-	2	-	2	-
C102.2	2	3	1	2	1	-
C102.3	1	-	1	2	1	-
C102.4	3	3	2	3	2	3
C102.5	2	2	1	2	2	2
C102.6	1	-	2	2	-	1
Average	1.7	2.7	1.5	2.2	1.6	2.0

ENERGY AND CLIMATE CHANGE
MEMT-103

Max. Marks: 60+40
Total Credits- 04
Time: 3 Hours

Objectives: The aim of this course is to provide the knowledge of impacts of use of different energy resources on environment, recent energy scenarios, global climate change, its impacts and mitigation strategies. The students will be able to understand the trends in energy related carbon emissions, carbon trading and climate change mitigation measures.

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

CO1: Learn about similarities and differences across the fields of climate, energy and environment with a focus on climate change.
CO2: Understand, analyse and compare the trends of carbon emission at national and international levels.
CO3: Determine the production of green house gases based on energy consumption patterns.
CO4: Identify impacts of climate change on human societies and natural ecosystems.
CO5: Describe the main processes involved in climate change and climate modelling.
CO6: Describe the ethical, scientific, and policy strengths and weaknesses of current and proposed mitigation and adaptation strategies.
CO7: Understand main aspects on climate regulation with focus on its impact on the energy sector.
CO8: Understand the possibilities for sustainable development in terms of future energy use.

Note:-
For final theory exam, time allotted will be of 3 hours and nine questions will be set. Question No.1 (objective/short answer type) covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each Unit.
The candidates will be required to attempt Q.No.1 and any four, selecting one question from each unit. All the questions will carry equal marks.

Unit-I

Energy and carbon emissions, World energy use and current energy scenario, Trends in energy use of oil, coal and gas, Energy use and air quality, Nuclear energy and environment, Fission and fusion, Clean Technology: Environmental Life Cycle Assessment.

Unit–II

Global climate change**:** Greenhouse effect, greenhouse gases: sources, trends, radiative forcing, warming potential of gases.
Photosynthetic mechanism and global climate change, Impacts of global warming: Polar ice caps and melting of glaciers, sea level increase, weather extreme, ecosystems, human health, coral reef bleaching, surface ocean chemistry, Biogenic calcification in oceans.

Unit–III

Tools to study climate change: Climate change modelling and general circulation models.Mitigation strategies for global warming; Biological Carbon Sequestration, Carbon Sequestration in geological formations, role of forests and dry lands in Carbon Sequestration, carbon capture and storage technologies. Geoengineering

Kyoto protocol, CDM and carbon trading.

Unit-IV

CO_2 challenge: Contribution by source; contribution by national and international sector; Carbon intensity and emission scenarios; Global warming as an energy problem; Energy efficiency; Energy transition and carbon content reduction; impact of climate change on energy demand; environmental impacts of energy consumption. Sustainable low carbon future; role of IPCC .

Suggested Reading:

1. Cleveland, C. J. 2008. *Encyclopedia of Energy*, Elsevier, New Delhi.
2. Goudie, A. S. and Cuff, D. J. 2002. *Encyclopedia of global change*, Oxford, New York.
3. IPCC (Intergovernmental Panel on Climate Change) 1990. *Climate Change: The IPCC Assessment*. Cambridge University Press, Cambridge.
4. Sorokhtin, O.G.,Chilingar, G.V. and Khilyuk, L.F. 2007. *Global warming and global cooling: Evolution of climate and earth*, Elsevier, Netherland.
5. Fouquet R. 2015, *Handbook on Energy and Climate Change*, Edward Elgar Publishing, UK.
6. Cherian A. 2015, *Energy and Global Climate Change: Bridging the Sustainable Development Divide*, Wiley Publisher, New York.

Teaching-Learning Process

- **Lectures:** Supported by black board teaching, power point presentations, related videos and demonstrations
- **Assignments and exercises**
- **Test:** Knowledge of the students is tested through surprise tests, quiz and session tests.

CO-PO MAPPING for MEMT 103

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
C103.1	3	1	1	2	2	2
C103.2	3	1	-	3	-	3
C103.3	2	-	-	2	2	3
C103.4	3	2	2	3	2	3
C103.5	3	2	-	3	1	3
C103.6	1	-	3	2	2	2
C103.7	2	1	-	3	-	2
C103.8	1	2	1	3	-	2
Average	2.25	1.5	1.75	2.63	1.8	2.5

CO-PSO MAPPING for MEMT 103

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
C103.1	2	1	2	1	1	1
C103.2	2	-	2	1	-	1
C103.3	2	1	3	1	-	2
C103.4	1	-	1	1	-	3
C103.5	2	-	2	-	2	3
C103.6	3	2	1	2	2	2
C103.7	2	2	2	3	1	1
C103.8	3	2	2	3	2	1
Average	2.13	1.6	1.88	1.71	1.6	1.75

RESEARCH TECHNIQUES AND QUANTITATIVE METHODS
MEMT-104

Max. Marks: 60+40
Total Credits: 04
Time: 3 Hours

Objectives:
The course provides the students knowledge on principles of spectroscopic and chromatographic techniques and their applications in environmental analysis; knowledge on different statistical techniques, sampling and analytical methods for environmental components. The students will acquire skills in handling of instruments, statistical tools, techniques and models.

Outcomes: On successful completion of this course, the students will be**:**

CO1 Able to understand the principles and handling of different analytical instruments and techniques used in the environmental (air, water and soil) analysis, and define the terms associated with the instrumentation.
CO2 Able to understand the applications and limitations of widely used instrumentation of spectroscopy, chromatography and microscopy.
CO3 Trained on the theory and practice of descriptive and inferential statistical tools and techniques to analyze environmental data and deriving meaningful conclusions.
CO4 Capable to understand the basics and types of experimental design for data collection under different environmental conditions.
CO5 Equipped with different methods used in the sampling of air, water and soil.
CO6 Able to learn about methods to assess ecological status of a site by measuring plant biomass and productivity, and soil microbial diversity, soil enzymes and soil carbon.

Note:-
For final theory exam, time allotted will be of 3 hours and nine questions will be set. Question No.1 (objective/short answer type) covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each Unit. The candidates will be required to attempt Q.No.1 and any four, selecting one question from each unit. All the questions will carry equal marks

Unit - I

Principles and applications of spectroscopy: UV-Vis, Spectrophotometry, Flame Photometry, Atomic Absorption Spectrophotometry (AAS), Colorimetry, Fluorometry, Inductively Coupled Plasma – Atomic Emission Spectroscopy (ICP – AES), Inductively Coupled Plasma – Mass Spectroscopy (ICP – MS).

Unit - II

Chromatography: Principles and applications of chromatographic techniques: (a) Paper (b) Thin Layer Chromatography (TLC)(c) Column (d) Gel (e) Gas Chromatography (GC) and (f) High Performance/Pressure Liquid Chromatography (HPLC) Microscopy: Optical, Phase Contrast, Automation method of analysis. Vocational prospects of instrumentation.

Unit - III

Types of data and measurement level; Statistical applications in environmental data analysis, , Measures of Central Location and Dispersion, Probability, Correlation, Significance Test for Correlation, Regression, Standard error of estimate, Null hypothesis and Error Types, Statistical significance, t-test - test of difference between means of two populations Chi-square

test; Analysis of variance (ANOVA).

Unit - IV

Principles of experimental design randomization, replication and local control, Types of experimental design- CRD, RBD, LSD, Simple factorial design; Analysis of experimental designs. Sampling methods for water, air and soil analysis; Methods of vegetation analysis, Methods of estimating plant biomass and productivity, Methods of Soil Analysis - soil microbial diversity, soil enzymes and soil carbon. Vocational opportunities of statistical techniques/models.

Suggested Readings:

1. Gomez, K.A. and Gomes, A.A. 1984. Statistical Procedures for Agricultural Research, John Wiley and Sons, New York.
2. Hoshmand,A.R. 1998. Statistical Methods for Environmental and Agricultural Sciences, CRP Press, New York.
3. John, W. & Mark, M. (eds). 2004. Environmental Modeling: Finding Simplicity in Complexity, John Wiley and Sons Inc., New York.
4. Zhang, C. 2007. Fundamentals of Environmental Sampling and Analysis, John Wiley and Sons, New Jersey.
5. Hobart H. Willard, Lynne L. Merritt Jr., John A. Dean, Frank A. Settle Jr. 1988, Instrumental Methods of Analysis (Chemistry), Wadsworth Publishing Company, California.

Teaching-Learning Process

- **Lectures:** Supported by black board teaching, power point presentations, related videos and demonstrations.
- **Assignments and exercises**
- **Test:** Knowledge of the students is tested through surprise tests, quiz and sessional tests.

CO-PO MAPPING for MEMT 104

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
C104.1	3	3	2	1	-	3
C104.2	3	3	2	2	-	3
C104.3	3	3	2	3	-	3
C104.4	2	1	2	1	-	2
C104.5	2	3	1	3	-	3
C104.6	2	2	1	2	2	3
Average	2.5	2.5	1.67	2	2	2.83

CO-PSO MAPPING for MEMT 104

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
C104.1	2	2	3	1	2	3
C104.2	1	-	2	-	-	2
C104.3	1	2	3	2	2	3
C104.4	1	1	2	-	-	2
C104.5	2	-	2	2	1	3
C104.6	2	1	1	1	1	2
Average	**1.5**	**1.5**	**2.17**	**1.5**	**1.5**	**2.5**

ENVIRONMENTAL ASSESSMENT AND MANAGEMENT
MEMT-201

Max. Marks: 60+40
Total Credits: 04
Time: 3 Hours

Objectives:
The aim of this course is to impart knowledge on Environmental Impact Assessment process and methodology, impacts of different industries on environment, environmental Auditing and role of judiciary in environmental protection in Indian context. The students will be able to identify impacts of different industries on environment and understand Environmental Management systems (EMS) and strategies of sustainable development.

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

CO1. Develop foundation on the concept and process of environmental impact assessment (EIA).
CO2. Equip with various methods used in the prediction and analyses of data for the environmental impact assessment.
CO3. Explain the role and importance of environmental management systems for a project or an activity.
CO4. Use the concept of sustainability in different areas of a project.
CO5. Practice EIA that examines the environmental consequences of development actions, in advance.
CO6. Carry out energy and environmental auditing of the industries.

Note:-
For final theory exam, time allotted will be of 3 hours and nine questions will be set. Question No.1 (objective/short answer type) covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each Unit. The candidates will be required to attempt Q.No.1 and any four, selecting one question from each unit. All the questions will carry equal marks.

UNIT-I
Approaches, objectives, principles and frameworks. Purposes and aims of environmental impact assessment, EIA methodology, EIA processes: Project screening, scoping, base-line data, impact identification: prediction, evaluation, valuation of environmental impacts, mitigation, public participation, presentation, review and decision making, monitoring and auditing.

UNIT -II
Environmental Management Plan, Environmental components of EIA. Environmental procedures in India; Impact, identification and methods, Case studies of EIA of hydroelectric dam and river valley project, Thermal power plants and petroleum exploration,; Types of environmental audits ; Environmental audit and EIA. National Environmental Policy - 2006, EIA notifications.

UNIT-III
Energy audits-energy conservations; Provision of energy conservation Act, 2001, List of energy Intensive industries and other establishments, Physical and operational data for the facility, Energy audit procedure, safety considerations, safety checklist, conducting the audit visit in industries. Primary identification of energy conservation opportunities: Post-audit

analysis, energy audit report, energy audit report format, energy action plan. Institutional designs for renewable energy resources.

UNIT-IV

Environmental management systems in India, ISO-14001. Environmental sustainability - dimension and sustainability models. Environmental sustainability indicators, sustainability index, strategies for sustainable development, Traditional knowledge systems for sustainable development. Introduction to environmental law and environmental protection act in India. Role of Judiciary in environmental conservation in India. Vocational prospects of EIA and EMS.

Suggested Readings:

1. Canter, L.W. 1996. Environmental Impact Assessment. 2nd edition, McGraw–Hill, New York.
2. Glasson, J., Therivel R. and Chadwick A. 1994. Introduction to Environmental Impact Assessment. UCL Press. London.
3. Morgan, R.K. 2002. Environmental Impact Assessment: A Methodological Perspective, Kluwer Academic Publishers, London.
4. Morris, P. and Thesivel, R. (Eds.) 2001. Methods in Environmental Impact Assessment. UCL Press, London.
5. Treweek, J. 1999. Ecological Impact Assessment. Blackwell Science, UK.
6. Christopher S. and Mark Y.2002. Installing Environmental Management Systems. EarthScan London.
7. Barrow, C. J. 2005. Environmental Management and Development, Taylor and Francis Group, London and New York.

Teaching-Learning Process

- **Lectures:** Supported by black board teaching, power point presentations, related videos and demonstrations.
- **Assignments and exercises**
- **Test:** Knowledge of the students is tested through surprise tests, quiz, sessional tests and seminars.

CO-PO MAPPING for MEMT 201

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
C201.1	3	-	-	2	1	2
C201.2	3	-	2	3	-	3
C201.3	2	-	-	2	-	3
C201.4	2	2	1	2	2	2
C201.5	2	1	-	3	-	3
C201.6	3	-	-	2	-	3
Average	**2.5**	**1.5**	**1.5**	**2.3**	**1.5**	**2.7**

CO-PSO MAPPING for MEMT 201

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
C201.1	2	-	2	-	-	3
C201.2	2	1	3	1	-	3
C201.3	3	1	3	2	-	2
C201.4	2	2	1	2	2	2
C201.5	2	-	2	2	2	3
C201.6	3	2	3	1	3	3
Average	**2.3**	**1.5**	**2.3**	**1.6**	**2.3**	**2.7**

RENEWABLE ENERGY AND TECHNOLOGY
MEMT-202

Max. Marks: 60 + 40
Total Credits: 4
Time: 3 Hours

Objectives: The aim of this course is to provide the details regarding solar energy, solar photovoltaic conversion, design and analysis of PV cells, and other energy options i.e. wind, nuclear, tidal, geo-thermal, wave and tar and oil shale, biomass energy, biogas, biodiesel and hydrogen. The students will be able to understand energy options and techniques of harnessing and methods of generating energy from organic wastes.

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

CO1 Describe various energy alternatives like tar sands and oil shale, tidal energy, wave energy, ocean thermal energy and biomass energy.
CO2 Understand renewable energy types, energy storage and energy conversion systems.
CO3 Explain working, construction and design of energy collectors, absorbers and energy concentrators.
CO4 Design and analyze photovoltaic conversion like PV cells and solar power heaters.
CO5 Understand the concepts of wind energy systems, convertion to wind flow, and wind energy converters.
CO6 Apply the concepts of thermo and bio-chemical process along with newer technologies of biomass conversion to bio-fuels.

Note:-

For final theory exam, time allotted will be of 3 hours and nine questions will be set. Question No.1 (objective/short answer type) covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each Unit. The candidates will be required to attempt Q.No.1 and any four, selecting one question from each unit. All the questions will carry equal marks.

Unit-I

Energy alternatives, the solar option, the nuclear option, tar sands and oil shale, tidal energy, geo-thermal energy. Solar energy: Solar radiations, solar thermal conversion devices and storage, applications. Solar photovoltaic conversion, Wave energy and Ocean thermal energy conversion, Hydroelectric energy. Vocational prospects of renewable and alternate energy sector.

Unit-II

Indirect and direct solar energy conversion. Photovoltaic conversion: Optical effect of p-n junction, design and analysis of PV cell, PV cell fabrication, system design, Solar power heaters. Wind energy: Conversation to wind flow, wind energy converters, commercial wind power development, wind energy storage and transfer.

Unit-III

Solar energy collection and storage, Solar energy for industrial process heat. Industrial process heat- temperature requirement, consumption pattern. Designing thermal storage, transport of energy, concentrating solar collector system, industrial applications of concentrating collector. Designs of energy collectors, tracking systems, absorbers and energy concentrators.

Unit-IV

Biomass energy: Sources of biomass energy, Petroleum plants, Energy plantations, Production of biogas from organic wastes, biogas plant designing. Recent trends in biodiesel production. Bio- ethanol production: Lessons from national and international experience. Energy from organic wastes; recent techniques in bio gas, biodiesel, bio-ethanol, bio-hydrogen fuel.

Suggested Reading:

1. Chaudhuri, S. P. G. 2007. *Renewable Energy in the Sundarbans*, TERI.
2. Holechek, J.L., Cole, R. A., ans Fisher, V. 2000. *Natural resources*, Prentice Hall, New Jersey, USA.
3. Kothari, D.P., Singal, K.C. and Ranjan, R. 2008. *Renewable energy sources and emerging technologies*, Prentice hall, New Delhi.
4. Podobnik, B. 2006. *Global energy shifts*. TERI press.
5. Sorensen, B. 2006. *Renewable energy*, Elsevier Publication, New Delhi.

Teaching-Learning Process

- **Lectures:** Supported by black board teaching, power point presentations, related videos and demonstrations.
- **Assignments and exercises**
- **Test:** Knowledge of the students is tested through surprise tests, quiz, sessional tests and seminars.

CO-PO MAPPING for MEMT 202

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
C202.1	3	-	-	2	1	2
C202.2	3	-	1	2	1	2
C202.3	2	-	-	3	-	3
C202.4	1	-	-	3	2	3
C202.5	-	-	-	2	-	2
C202.6	3	-	2	3	2	3
Average	**2.4**	**-**	**1.5**	**2.5**	**1.5**	**2.5**

CO-PSO MAPPING for MEMT 202

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
C202.1	2	3	2	1	1	2
C202.2	3	3	1	2	3	2
C202.3	2	2	2	3	2	3
C202.4	2	2	2	2	2	3
C202.5	2	2	2	1	2	2
C202.6	3	2	1	3	2	2
Average	**2.3**	**2.3**	**1.7**	**2**	**2**	**2.3**

ENVIRONMENTAL REMOTE SENSING AND GIS

MEMT- 203

Max. Marks: 60+40
Total Credits: 04
Time: 3 Hours

Objectives:
The course provides students with an introduction to the principles and techniques of remote sensing and geographic information systems (GIS) and the application of these techniques to the various aspects of environment including the earth observation and analysis. The students will be able to understand the information embedded in remotely sensed data, its retrieval and geospatial analysis.

Outcomes: On completion of this course, the students will have:

CO1. A base for understanding Remote Sensing (RS) and Geographic Information System (GIS) as an IT tool, its purpose and utility for the mankind in general and in geospatial study of environmental components, specifically.
CO2. An understanding of types, process, platforms and sensors used in RS with an emphasis on optical and microwave remote sensing.
CO3. An understating about the elements and techniques of image interpretation of different scales and resolution, concepts and techniques of digital image processing, photogrammetry and aerial photography.
CO4. Profound knowledge about ground verification techniques, spatial and non-spatial data types and sources of different domains and its integration and analysis in a GIS environment, and problem-based designing and management of GIS projects.
CO5. Basic competency in skills with functional knowledge to carry out RS and GIS based projects, and usage of GPS.
CO6. Familiarization about the scope of RS and GIS technology in the field of environment and energy management.

Note:-
For final theory exam, time allotted will be of 3 hours and nine questions will be set. Question No.1 (objective/short answer type) covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each Unit. The candidates will be required to attempt Q.No.1 and any four, selecting one question from each unit. All the questions will carry equal marks.

Unit-I

Principle, basics and components of Remote Sensing, Electromagnetic spectrum, Atmospheric windows, scattering, Spectral reflectance and emission, Energy-matter interaction. Basic principles of global positioning system.

Unit – II

Remote Sensing - processes, platforms, scanners and sensors; Systems for data collection - passive and active remote sensing; Multispectral Remote Sensing; Concepts and applications of Microwave and LiDAR Remote sensing.

Unit-III

Elements of visual image interpretation, Digital image processing, Image Classifications, Ground truthing, Geo-referencing. Photogrammetry: Basic concepts, Types of aerial photographs. Application of Remote Sensing in Energy, Natural resource management, Disaster management, Urban planning, Coastal zone management etc.

Unit-IV

GIS- basic concept. raster and vector data; Analytical modeling in GIS. GIS project management - problem specific design, implementation and evaluation. GIS application in Natural resource management, Biodiversity, EIA, Solid waste management, Disaster management etc. Vocational prospects of remote sensing and GIS.

Suggested Readings:

1. James B. Campbell and Randolph H. *Introduction to remote sensing*, Wynne, Guilford Press (5th ed., 2011), New York.
2. Thomas M. Lillesand, Ralph W. Kiefer, Jonathan W. Chipman. *Remote Sensing And Image Interpretation,* 7th Ed., 2015, John Wiley & Sons, USA.
3. An Introduction to Geographical Information Systems, Heywood Ian, Pearson Education India, 2010, New Delhi.
4. Harvey F.*A Primer of GIS: Fundamental Geographic and Cartographic Concepts*, TheRawat Publication; 2009 edition (2009).

Teaching-Learning Process

- **Lectures:** Supported by black board teaching, power point presentations, related videos and demonstrations.
- **Assignments and exercises**
- **Test:** Knowledge of the students is tested through surprise tests, quiz, sessional tests and seminars.

CO-PO MAPPING for MEMT 203

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
C203.1	-	2	-	2	-	2
C203.2	-	2	-	2	-	3
C203.3	-	1	-	2	-	3
C203.4	-	-	-	2	-	3
C203.5	-	2	-	3	2	3
C203.6	-	2	-	3	2	3
Average	**-**	**1.8**	**-**	**2.3**	**2**	**2.8**

CO-PSO MAPPING for MEMT 203

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
C203.1	2	1	2	3	1	3
C203.2	2	-	1	2	1	3
C203.3	2	-	2	2	-	3
C203.4	2	-	2	2	-	3
C203.5	3	2	3	3	2	3
C203.6	3	2	3	3	3	3
Average	**2.3**	**1.7**	**2.2**	**2.5**	**1.8**	**3**

ENVIRONMENTAL BIOTECHNOLOGY AND BIOFUELS
MEMT-204

Max. Marks: 60+40
Total Credits: 04
Time: 3 Hours

Objectives:
The proposed course is designed to teach students, the microbiological and biotechnological principles of treatment technologies for clean-up of contaminated environments and to recover the valuable resources for the welfare of human society. The students will able to understand the applications of environmental biotechnology in the different areas of bioremediation, biofuel production and biorefineries.

Outcomes: On completion of this course, the students will able to:
CO1: Understand the applications of environmental biotechnology in different areas of bioremediation.
CO2: Understand the concept and application of biosensors to assess the pollutants in environment.
CO3: Demonstrate the understanding of biotechnological tools used in forest management and biodiversity conservation.
CO4: Understand the concept of biological treatment for wastewater.
CO5: Demonstrate the basics of GMOs, biosafety guidelines and IPR.
CO6: Understand the concept of biofuel production and biorefineries.

Note:-
For final theory exam, time allotted will be of 3 hours and nine questions will be set. Question No.1 (objective/short answer type) covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each Unit. The candidates will be required to attempt Q.No.1 and any four, selecting one question from each unit. All the questions will carry equal marks.

Unit-I
Microbes and environmental management. Biodegradation of macromolecules and xenobiotics, Bioremediation techniques: aerobic and anaerobic, Bioremediation of metal contaminated sites and spilled oil, Biosorption, Bioaccumulation, Bioleaching and Biomining for recovery of resources, Phytotechnology.

Unit-II
Biosensors in detection of Environmental Pollution – BOD sensor, Methane biosensor, Ammonia and nitrate biosensor. Bioreactors designs, types and environmental applications. Micropropagation and cloning of plants – application in forestry; Biotechnology in preservation of bio-diversity; Cryopreservation and Gene banks.

Unit-III
Wastewater treatment technologies; Biological Processing of waste water, Biotechnology for solid, hazardous and radioactive waste management, Biodegradable plastics. Biotechnology for wasteland management; Biofertilizers and Biopesticides and IPM. GMO's, Biosafety and Bioethics guidelines. IPR and environment. Vocational prospects of environmental biotechnology.

Unit-IV

Biofuels: Biodiesel fuels, their origin, chemical and physical properties; Biodiesel production; Advantages and disadvantages of biodiesel; Storage and use of biodiesel; Bioethanol production, properties and its limitations. Biorefinery concept – biomass derived chemical products. Biomass gasification; Policy issues in biofuels, Indian Biofuel Programme.

Suggested Readings:

1. Armstrong, F. and Blundell, B. K. 2007. *Energy……beyond oil*, Oxford, New York.
2. Bhojvaid, P.P. 2007. *Biofuels Towards a Greener and Secure Energy Future* TERI Press, New Delhi.
3. Buchanan, G. and Jones 2004. *Biochemistry and Molecular Biology of Plants,* IK International Pvt. Ltd., New Delhi.
4. Kaushik, N. 2004. *Biopesticides for Sustainable Agriculture, Prospects and Constraints* TERI Press, New Delhi.
5. Nelson, G.C. 2001. *Genetically Modified Organisms in Agriculture: Economics and Politics*. Academic Press.
6. Spiros, N.A. and Reineke, W. 2002. *Biotechnology for the Environment: Soil Remediation*, Kluwer Academic Publishers, Springer-Verlag , New York.

Teaching-Learning Process

- **Lectures:** Supported by black board teaching, power point presentations, related videos and demonstrations.
- **Assignments and exercises**
- **Test:** Knowledge of the students is tested through surprise tests, quiz, sessional tests and seminars.

CO-PO MAPPING for MEMT 204

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
C204.1	3	-	-	2	3	3
C204.2	3	-	-	2	3	3
C204.3	3	2	2	2	3	3
C204.4	2	1	2	3	2	2
C204.5	2	-	3	2	2	3
C204.6	3	-	2	3	2	2
Average	**2.7**	**1.5**	**2.3**	**2.3**	**2.5**	**2.7**

CO-PSO MAPPING for MEMT 204

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
C204.1	2	3	2	2	2	3
C204.2	2	2	2	2	1	3
C204.3	2	2	2	2	-	3
C204.4	2	-	1	-	1	3
C204.5	1	-	1	1	-	3
C204.6	3	3	2	3	3	3
Average	**2**	**2.5**	**1.7**	**2**	**1.8**	**3**

ENERGY CONSERVATION AND EFFICIENT SYSTEMS
MEMT- 301 (EL-1A)

Max.Marks: 60+40
Total Credits: 04
Time: 3 Hours

Objectives:
The course provides the students, knowledge on principles and practices of energy conservation, renewable energy systems and efficiency of various energy related processes. The students will be able to learn about global/local energy issues, opportunity and techniques of saving energy, energy auditing for applications in industries and research.

Outcomes: On completion of this course, the students will have:

CO1 Knowledge on fundamentals of conservation of energy, energy conservation programmes and different energy scenarios.
CO2 Knowledge on technologies of energy conservation and sustainable energy.
CO3 Awareness on the basics of energy efficiency, methodologies to improve energy efficiency and its effects.
CO4 Understanding on the concepts of energy efficient buildings and utilities such as pumps, motors, fans windows, lighting, compressed air systems, refrigeration and air conditioning system.
CO5 Knowledge about different renewable energy systems such as solar thermal and solar photovoltaic, wind, ocean wave and tidal, geothermal, biomass, nuclear and their applications.
CO6 Familiarization with Bureau of Energy Efficiency (BEE) and star rating concept.

Note:-
For final theory exam, time allotted will be of 3 hours and nine questions will be set. Question No.1 (objective/short answer type) covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each Unit. The candidates will be required to attempt Q.No.1 and any four, selecting one question from each unit. All the questions will carry equal marks.

Unit –I

Conservation of energy: overview, concept and principle of energy conservation, Laws of Thermodynamics, Energy conservation as preservation of resources, Conservation measures for energy, Energy scenario: energy pricing in India, energy sector reforms, managing an effective energy conservation programme, Material and energy balance.

Unit-II

Energy efficiency: introduction, definition and importance, benefits of energy efficiency, potential for energy efficiency, industrial energy efficiency, The effect of efficiency improvement on primary energy demand, Energy distribution, generation and Demand Side Management (DSM). Energy analysis of buildings.

Unit-III

Sustainable energy technologies and energy efficiency, Energy intensity, Pathways to improve energy intensity. Cogeneration: concept, options (steam/gas, turbine, diesel engine based). Reduction of energy loss and energy recovery in urban ecosystems. Energy efficiency in buildings (green building), solar water heating system.

Unit-IV

Wave tidal power technologies. geothermal, nuclear, alternative transport fuels, Energy efficient vehicles technologies - Advance ICE, Hybrid electric, Plug-in hybrid, Flex-fuel, Fuel Cell technology, energy efficient motors, windows, lighting. Energy efficient pumps, fans, compressed air systems, refrigeration and air conditioning systems. Waste heat recovery. Bureau of energy efficiency, Concept of Star rating.

Suggested Reading:

1. Cleveland, Cutler J. 2008. *Encyclopedia of Energy*, Elsevier, New Delhi.
2. Kothari. D.P., Singal, K.C. and Ranjan, R. 2008. *Renewable Energy Sources and Emerging Technologies*, Prentice hall, New Delhi.
3. Kreithand F., Goswami D.Y., *Handbook of Energy Efficiency and Renewable Energy*, C.R.C. Press.
4. Kreith. F., Goswami. D.Y.2007. *Handbook of Energy Efficiency and Renewable Energy*, Taylor & Francis Group, LLC
5. Owen, Oliver S. and Chiras, Daniel D. (1990). *Natural Resource Conservation-An Ecological Approach* Macmillon, New York.
6. Wiley J.S., Turner W.C., *Energy Management Handbook*.

Teaching-Learning Process

- **Lectures:** Supported by black board teaching, power point presentations, related videos and demonstrations.
- **Assignments and exercises**
- **Test:** Knowledge of the students is tested through surprise tests, quiz, sessional tests and seminars.

CO-PO MAPPING for MEMT 301-EL-1A

	PO1	PO2	PO3	PO4	PO5	PO6
C301EL1A.1	-	1	-	2	-	2
C301EL1A.2	-	-	-	3	2	2
C301EL1A.3	-	-	2	3	2	3
C301EL1A.4	-	-	-	3	-	3
C301EL1A.5	-	2	1	3	1	3
C301EL1A.6	-	-	-	1	-	2
Average	**-**	**1.5**	**1.5**	**2.5**	**1.7**	**2.5**

CO-PSO MAPPING for MEMT 301-EL-1A

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
C301EL1A.1	3	2	1	2	1	-
C301EL1A.2	3	3	2	3	2	2
C301EL1A.3	2	3	-	3	3	3
C301EL1A.4	2	1	-	2	2	2
C301EL1A.5	2	3	2	2	3	2
C301EL1A.6	1	-	2	-	2	1
Average	**2.2**	**2.4**	**1.8**	**2.4**	**2.2**	**2**

Environmental Bioremediation Technology
MEMT-301 (EL-1B)

Max. Marks: 60 + 40
Total Credits-04
Time: 3 Hours

Objectives:
The aim of this course is to make students understand biotransformation, biodegradation of xenobiotics, bioremediation strategies and their applications for cleanup of environmental contaminants. The students will be able to understand the various applications of bioremediation technologies and the kinetics and modelling of biodegradation.

Outcomes: On completion of this course, the students will able to:
CO1: Understand the characteristics and bioremediation of xenobiotic compounds.
CO2: Develop skills to apply the different bioremediation techniques for the degradation of toxic contaminants.
CO3: Understand the process of phytoremediation and role of algae and fungi in bioremediation.
CO4: Understand the application of genetic engineering in phytoremediation.
CO5: Understand the bioremediation processes for gaseous pollutants, role and applications of biosensors in remediation technologies

Note:-
For final theory exam, time allotted will be of 3 hours and nine questions will be set. Question No.1 (objective/short answer type) covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each Unit. The candidates will be required to attempt Q.No.1 and any four, selecting one question from each unit. All the questions will carry equal marks.

Unit-I

Introduction to bioremediation, Historical development of environmental bioremediation, Requirements for bioremediation, Constraints and priorities of bioremediation, Applications of bioremediation technologies.Xenobiotic compounds, their structure and persistance in environment, Oil spills, Oil products in environment. Biodegradation- principles and mircobiology; Microconversions of xenobiotics

Unit-II

Biotransformation of pesticides and hydrocarbons, Biodegradation kinetics, Bioavailability, Biomineralization, Testing for biodegradability, Numerical modelling of biodegradation. Biological processing of waste water, Bioreactors – designs used for treatement of sludge and removal of metals from waste water. Biodegradable plastic, Biodegradation of PAH in environment.

Unit-III

Bioremediation strategies – biostimulation and bioaugmentation, Bioremediation techniques *in-situ* and*ex-situ*. Bioremediation of organic and metal contaminated environments. Metal toxicityand bioavailability. Biosorption and precipitation.Bioremediation technologies for heavy metaland radionuclides removal.Phytoremediation and its processes, role of phytochelatins.Applications of genetic engineering in phytoremediation. Algal and fungal based bioremediation.

Unit-IV

Gaseous bioremediation, biofilms, bioscrubbers, bioventing, Soil Vapour Extraction (SVE), Water recirculation systems, Air sparging, Biobarriers, Composting, Phytoremediation for air technologies.Role of biosensors in bioremediation technologies, Biofilms and their applications.

Suggested Reading:

1. Scragg A., 2008. *Environmental Biotechnology*, Oxford Univesity Press. New York
2. Singh S.N., Tripathi R.D., 2007. *Environmental Bioremediation Technologies*, Springer, New York.
3. Mohapatra P.K. 2007. *Textbook of Environmental Biotechnology*, I.K. Publishing House, New Delhi.
4. Olguin E.J., Sanchez G., Hernandez E. 2005. Environmental Biotechnology and Cleaner Processes, Replika Press, Kundli.
5. Trivedi P.C. 2008. Pollution and Bioremediation, Sheetal Printer, Jaipur, India.

Teaching-Learning Process

- **Lectures:** Supported by black board teaching, power point presentations, related videos and demonstrations.
- **Assignments and exercises**
- **Test:** Knowledge of the students is tested through surprise tests, quiz, sessional tests and seminars.

CO-PO MAPPING for MEMT 301-EL-1B

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
C301EL1B.1	2	2	1	1	2	2
C301EL1B.2	3	3	3	3	2	3
C301EL1B.3	3	3	1	2	3	3
C301EL1B.4	3	3	1	2	3	3
C301EL1B.5	3	2	2	2	2	3
Average	**2.8**	**2.6**	**1.6**	**2.0**	**2.4**	**2.8**

CO-PSO MAPPING for MEMT 301-EL-1B

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
C301EL1B.1	2	-	-	1	2	2
C301EL1B.2	3	2	2	2	3	3
C301EL1B.3	2	2	3	2	1	2
C301EL1B.4	2	1	2	3	1	2
C301EL1B.5	2	1	3	3	1	2
Average	**2.2**	**1.5**	**2.5**	**2.2**	**1.6**	**2.2**

ENVIRONMENTAL POLICIES, LAW AND IMPACT ASSESSMENT
MEMT- 301 (EL - 1C)

Max.Marks: 60+40
Total Credits: 04
Time: 3 Hours

Objectives:

The aim of the course is to make the students understand the environmental policies and planning, environment impact assessment and environment clearance process. The course will enable students to apply the knowledge of EIA and environment clearance for systematic assessment of industrial and infrastructural projects.

Outcomes: A student after taking up this course would be able

CO1: To acquire values and attitude towards understanding various environmental policies and constitutional framework governing environment in India.

CO2: To learn and apply various environmental legislations/acts in India.

CO3: To understand the emerging environmental issues and key international treaties for environment protection.

CO4: To clarify the concepts of EIA and develop the professional skills necessary to enable them to undertake environment impact assessment

CO5: Learn through a variety of professional tools used in predicting environmental impacts.

CO6: Experience their own perspective through various case-studies on impact assessment and developing critical thinking for shaping strategies for environmental management planning, environment auditing and risk assessment

CO8: To understand the recent trends in energy investment, pricing and energy utilisation through various policies and modelling.

CO9: To understand the energy conservation strategies and role of BEE (Bureau of Energy Efficiency) in conservation.

Note:-

For final theory exam, time allotted will be of 3 hours and nine questions will be set. Question No.1 (objective/short answer type) covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each Unit. The candidates will be required to attempt Q.No.1 and any four, selecting one question from each unit. All the questions will carry equal marks.

Unit –I

National and International environmental issues**,** International Conventions and Agreements on environmental issues: UNFCCC, Stockholm Conference, The Rio Earth Summit 2012 (Rio +20), Convention on Climate Change, Agenda 21, Kyoto Protocol, Montreal Protocol, Convention on Biological diversity, Ramsar Convention on Wetlands, The Environmental (Protection) Act1986, The Biological Diversity Act, 2002,Wild Life (Protection) Act, 1972.

Unit- II

Approaches, objectives, principles and frameworks of: Air (Prevention & control of pollution)Act, 1981, Motor Vehicle Act, 1988, The water (Prevention & control) Pollution Act, 1974,Solid wastes (Management and Handling) Rules, 2000, Coastal Regulation Zone Notification1991, Disaster Management Act, 2005. CPCB,BIS and APHA standards for air, water and soil; Scheme of labelling of Environment friendly product (Eco mark).

Unit – III

Energy policies in the country; Tariffs and subsidies; Energy utility interface; National Energy Plan, Energy Investment Planning & Energy pricing, Concept of Energy & Environment Management System (EEMS), Role of modelling in energy policy analysis, Role of BEE(Bureauof Energy Efficiency) in energy conservation.

Unit –IV

Environmental Impact Assessment, EIA guidelines of Ministry of Environment, Forest and Climate Change (MoEF&CC), Strategic Environmental Assessment and Cumulative Effects Assessment, Preparation of ISO Manuals for Industry; Integrating ISO 9000, ISO 14001 and OHSAS 18001, GRIHA(Green Rating for Integrated Habitat Assessment) - Guidelines.
Case studies: EIA for Metro Stations, IT Parks, Nuclear Power Plant and Infrastructure.

Suggested Reading:

1. Kathryn L. Schroder 2008 *Environmental Law* Thomson Delmar learning, New York.
2. Karen E. Makuch, Richard Pereira 2012. *Environmental & Energy Law* Wiley-Blackwell, UK.
3. MEA 2005. *Ecosystems and Human Well-being: health synthesis, a report of the WorldResources Institute*, Washington, D.C.
4. Singh, J.S., Singh S.P. and Gupta S.R. 2015. *Ecology, Environmental Science and Conservation,* S.Chand Publishers, New Delhi.

Teaching-Learning Process

- **Lectures:** Supported by black board teaching, power point presentations, related videos and demonstrations.
- **Assignments and exercises**
- **Test:** Knowledge of the students is tested through surprise tests, quiz, sessional tests and seminars.

CO-PO MAPPING for MEMT 301-EL-1C

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
C301EL1C.1	1	-	2	1	-	2
C301EL1C.2	-	-	2	2	-	2
C301EL1C.3	1	2	-	3	2	3
C301EL1C.4	-	-	2	3	2	3
C301EL1C.5	-	2	2	1	2	3
C301EL1C.6	2	2	2	3	2	3
C301EL1C.7	-	-	-	3	2	3
C301EL1C.8	2	-	1	2	1	3
Average	**1.5**	**2**	**1.8**	**2.3**	**1.8**	**2.8**

CO-PSO MAPPING for MEMT 301-EL-1C

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
C301EL1C.1	1	-	1	-	-	1
C301EL1C.2	2	-	-	-	-	2
C301EL1C.3	2	1	1	2	-	2
C301EL1C.4	2	-	2	1	1	3
C301EL1C.5	1	-	2	2	-	2
C301EL1C.6	2	1	2	1	1	2
C301EL1C.7	2	2	2	2	2	3
C301EL1C.8	2	2	2	2	2	2
Average	**1.75**	**1.5**	**1.71**	**1.67**	**1.5**	**2.13**

INDUSTRIAL ENERGY
MEMT-302 (EL - 2A)

Max. Marks: 60 + 40
Total Credits- 4
Time: 3 Hours

Objectives:

The aim of this course is to enable the students to understand different aspects of energy conservation and recovery systems in industries. The students will able to understand energy efficiency practices and technologies that can be applied at the component, process, facility, and organizational levels.

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

CO1 Understand energy conservation potential in various industries
CO2 Have a basic knowledge of energy storage systems and industrial safety measures
CO3 Identify energy savings opportunities in thermal and electrical systems
CO4 Apply the knowledge in waste heat recovery and heat exchanger networking
CO5 Understand hydrogen fuel technology
CO6 Apply the knowledge of energy saving measures in different energy intensive process industries

Note:-

For final theory exam, time allotted will be of 3 hours and nine questions will be set. Question No.1 (objective/short answer type) covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each Unit. The candidates will be required to attempt Q.No.1 and any four, selecting one question from each unit. All the questions will carry equal marks.

Unit-I

Types of energy; Energy conversion steps; Energy use in industrial operations; Energy conservation potential in various industries and commercial establishments - Energy intensive industries - an overview; End use energy efficiency. Energy Storage Systems - storage of mechanical energy, electrical energy, chemical energy, thermal energy; Industrial safety measures and ILO Convention and Recommendations in the furtherance of safety and health.

Unit-II

Industry energy systems, Properties of steam - Steam distribution (Assessment of steam distribution losses, Steam leakages, Steam trapping) - Condensate recovery and flash steam utilisation system. Identifying opportunities for energy savings. Thermal insulation. boiler – efficiency testing, excess air control, steam boiler monitoring. Electrical Systems: Demand control, power factor correction, load scheduling/shifting. Lighting, lighting levels, efficient options, fixtures, day lighting, timers, Energy efficient windows.

Unit-III

Waste Heat Recovery: Recuperators, regenerators, heat pipes, heat pumps. Cogeneration - concept, options (steam/gas turbines/diesel engine based), selection criteria, control strategy. Heat exchanger networking - concept of pinch, target setting, problem table approach, composite curves. Demand side management. Energy conservation in Pumps, Fans (flow control), Compressed Air Systems, Refrigeration and air conditioning systems, boilers, and furnaces.

Unit-IV

Hydrogen fuel technology- production of hydrogen from electrolysis and photochemical methods, hydrogen storage technologies, fuel cell systems, hydrides as fuels. Energy Saving Measures in Energy Intensive Process Industries − Pulp and Paper, Sugar, Textile, Fertilizer and their case studies. Chemical, Petrochemical Processes, Chlor-Alkali and their case studies. Aluminium, Iron and Steel, Cement and their case Studies; Railways, Ports, Transport Sector, Power Stations and their case studies.

Suggested Reading:

1. Zoran K. Morvay and Dusan D. Gvozdenac,2008 "Applied Industrial Energy and Environmental Management", John Wiley.
2. Guide book for "National Certification Examination for Energy Managers and Energy Auditors" 2007, Dr.Ambedkar Institute of Productivity, National Productivity Council, Chennai.
3. Doty S. and Turner W.C., 2012,"Energy Management Handbook" Eighth Edition, Wiley Eastern Publication, New York.
4. Dryden I.G.C. 1982, *"The Efficient Use of Energy"*, Butterworths, London,.

Teaching-Learning Process

- **Lectures:** Supported by black board teaching, power point presentations, related videos and demonstrations.
- **Assignments and exercises**
- **Test:** Knowledge of the students is tested through surprise tests, quiz, sessional tests and seminars.

CO-PO MAPPING for MEMT 302-EL-2A

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
C302EL2A.1	2	-	-	3	1	3
C302EL2A.2	-	-	2	3	2	3
C302EL2A.3	-	2	-	2	2	3
C302EL2A.4	-	-	1	3	2	3
C302EL2A.5	2	2	2	2	2	2
C302EL2A.6	-	-	-	2	2	3
Average	**2**	**2**	**1.7**	**2.5**	**1.8**	**2.8**

CO-PSO MAPPING for MEMT 302-EL-2A

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
C302EL2A.1	1	1	1	1	1	2
C302EL2A.2	1	-	2	2	2	3
C302EL2A.3	2	1	1	2	2	2
C302EL2A.4	2	2	2	3	3	2
C302EL2A.5	2	2	1	2	2	1
C302EL2A.6	3	-	2	3	3	3
Average	**1.83**	**1.5**	**1.5**	**2.17**	**2.17**	**2.17**

ENERGY FROM WASTE
MEMT-302 (EL-2B)

Max.Marks: 60+40
Total Credits: 04
Time: 3 Hours

Objectives:

The aim of this course is to give information about different sources of the waste which can be utilized in efficient energy generation. The students will get opportunity to know about the biochemical conversions, thermochemical conversions, biomass gasification and bioethanol production, generation of energy from the waste and their environmental impacts.

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

CO1 Understand different sources of wastes and various properties of wastes as a fuel
CO2 Select technologies for waste disposal and energy recovery from wastes
CO3 Apply the concepts of thermo and bio-chemical process along with newer technologies of energy generation from wastes.
CO4 Identify environmental impacts of energy generation techniques
CO5 Have knowledge of biofuels, their production and purification methods, and applications in the country economy.
CO6 Apply the knowledge about the operations of waste to energy plants

Note:-

For final theory exam, time allotted will be of 3 hours and nine questions will be set. Question No.1 (objective/short answer type) covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each Unit. The candidates will be required to attempt Q.No.1 and any four, selecting one question from each unit. All the questions will carry equal marks.

Unit-I

Definition, classification and sources of waste; physical, chemical and biological properties of waste as a fuel; Waste handling before thermal conversion, Preparation of recycled fuel, Mass combustion of waste, Combustion of recycled fuel. Emission reduction during combustion.

Unit-II

Technologies for solid waste disposal and recovery of energy from municipal solid waste and industrial waste, Organic waste blending systems, Utilization and treatment of fly ash, land-fill gas utilization in energy production. Energy generation from waste: Refuse Derived Fuel (RDF) - waste to energy- design and fuel analysis. Vocational prospects of waste to energy.

Unit-III

Biochemical conversions: sources of energy generation: industrial waste, agro residues; anaerobic digestion biogas production; types of biogas plant Thermochemical conversions: sources of energy generation, Industrial applications of gasifiers, Briquetting; utilization and advantages of briquetting; Environmental impacts of biochemical and thermochemical conversion.

Unit-IV

Biomass: procedures of characterization, Integrated biomass gasification for electricity generation. Bio-energy as byproduct of waste processing, bioenergy assessment; biomethanation from sludge digestion, types of reactors, UASBR (Upper Anaerobic Sludge Blanket Reactor), Biorefinery concept.

Alcohol fuels: vegetable oil as fuels, bioethanol production and technology; biodiesel, biohydrogen technology: potential of organic waste for hydrogen production; biofuel refining and technology; commercial biomass energy markets and economics**.**

Suggested Readings:

1. Lal B., Reddy MRVP, 2005. *Wealth from Waste*, Rajkamal Electric Press, Delhi.
2. Cleveland C.J., 2008. *Encyclopedia of Energy*, Elsevier, New Delhi
3. Bhatia S.C., 2007. *Solid and Hazardous Waste Management*, Nice Printing Press, Delhi.
4. Wall J.D., Harwood C.S., Demain A., 2008. *Bioenergy*, Printed in USA.

Teaching-Learning Process

- **Lectures:** Supported by black board teaching, power point presentations, related videos and demonstrations.
- **Assignments and exercises**
- **Test:** Knowledge of the students is tested through surprise tests, quiz, sessional tests and seminars.

CO-PO MAPPING for MEMT 302-EL-2B

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
C302EL2B.1	2	2	2	-	2	1
C302EL2B.2	2	2	-	3	3	3
C302EL2B.3	3	3	2	2	2	3
C302EL2B.4	-	-	-	2	2	2
C302EL2B.5	3	3	2	2	3	3
C302EL2B.6	2	2	-	2	3	3
Average	**2.4**	**2.4**	**2**	**2.2**	**2.5**	**2.5**

CO-PSO MAPPING for MEMT 302-EL-2B

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
C302EL2B.1	1	1	1	-	1	1
C302EL2B.2	3	3	2	3	2	3
C302EL2B.3	2	2	2	3	3	3
C302EL2B.4	1	-	2	1	-	2
C302EL2B.5	2	3	1	3	2	2
C302EL2B.6	2	1	2	3	3	3
Average	**1.8**	**2**	**1.7**	**2.6**	**2.2**	**2.3**

ENVIRONMENTAL MODELLING
MEMT- 302 (EL-2C)

Max. Marks: 60+40
Total Credits: 04
Time: 3 Hours

Objectives:
The course provides students with advance knowledge on predictive and forecasting modelling tools and techniques to be used in environmental and energy systems and for their analysis. The students will develop a broader understanding of tools of environmental modelling and techniques used for applications in predictive and forecasting services.

Outcomes: On completion of this course, the students will have:

CO1 A basic understanding on model development and about the concepts of system and simulation.
CO2 An understanding about different modelling practices such as simple and complex calculation models, linear and non-linear models, optimization models, probabilistic models.
CO3 An understating about the predictive and forecasting modelling of air pollution and its transport.
CO4 Knowledge on surface water modeling and groundwater modeling techniques.
CO5 Basic competency in skills with application of modelling techniques in the different environmental applications such as natural resource management, climate change, forecast services, and energy policy analysis.

Note:-
For final theory exam, time allotted will be of 3 hours and nine questions will be set. Question No.1 (objective/short answer type) covering the entire syllabus, will be compulsory. The remaining eight questions will be set unit-wise with two questions from each Unit.The candidates will be required to attempt Q.No.1 and any four, selecting one question from each unit. All the questions will carry equal marks.

Unit I
Principles of model development and solution for environmental systems (air, water and soil), Basic steps in the model development: problem definition, model design and development and evaluation. Concept of system modeling and simulation. Simple and complex calculation models, linear and non-linear models, Time series analysis.

Unit II
Optimization models and their evaluation, Probabilistic methods for modeling: weibull, gamma and lognormal models. Predictive and Forecasting modeling of air pollution, hydrology and climate change. Gaussian plume model, gradient transport, eddy diffusion modeling, modelling fugitive emissions,

Unit III
Modeling of Spatio-Temporal Dynamics, Surface water modeling: DO sag model, BOD model, Eutrophication model, Elements of groundwater modeling, Case study: predicting the mixing

and dispersion of air pollutants in the environment, GIS-based human exposure modeling system for traffic air pollution.

Unit IV

Model applications in the area of climate change, air and water pollution, biodiversity, and natural resource management. Forecast service, Social and economic aspects of environmental modelling, Role of modeling in energy policy analysis.

Suggested Readings:

1. John, W. and Mark, M. (eds). 2004. Environmental Modeling: Finding Simplicity in Complexity, John Wiley and Sons Inc., New York.
2. Andrew Ford, 2009. Modeling the Environment, Island Press; 2 edition
3. Jo Smith, Peter Smith, 2007. Environmental Modelling: An Introduction. Oxford University Press.
4. Fung, F., Lopez, A. and New, M. (eds.). 2011. Modelling the impact of climate change on water resources. Willey-Blackwell Ltd., U.K.
5. Barnsley, Michael, J. 2007. Environmental Modelling: A practical introduction. CRC Press, USA

Teaching-Learning Process

- **Lectures:** Supported by black board teaching, power point presentations, related videos and demonstrations.
- **Assignments and exercises**
- **Test:** Knowledge of the students is tested through surprise tests, quiz, sessional tests and seminars.

CO-PO MAPPING for MEMT 302-EL-2C

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
C302EL2C.1	2	1	-	3	3	2
C302EL2C.2	2	1	-	3	3	3
C302EL2C.3	2	2	-	2	2	3
C302EL2C.4	2	2	-	2	2	3
C302EL2C.5	2	2	2	3	3	3
Average	**2**	**1.6**	**2**	**2.6**	**2.6**	**2.8**

CO-PSO MAPPING for MEMT 302-EL-2C

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
C302EL2C.1	1	-	2	1	1	1
C302EL2C.2	3	-	2	1	-	2
C302EL2C.3	2	-	2	2	-	2
C302EL2C.4	2	-	2	2	-	2
C302EL2C.5	3	2	3	3	2	3
Average	**2.2**	**2**	**2.2**	**1.8**	**1.5**	**2**

Dissertation Work
MEMT-401

Max. Marks:250
Total Credits: 10

Objectives

The dissertation provides practical knowledge and skills in the area of energy and environment in the industry or research institute or consultancy. The students receive analytical and problem-solving skills to implement solutions to firm-specific problems which, in turn, also enhance their career prospects.

Outcomes: On completion of the dissertation, the students will be able to:

CO1 Implement knowledge and skills they learnt during the programme in solving specific energy and environment management problems.

CO2 Develop competencies for research, innovations and practical applications.

CO-PO mapping matrix for MEMT-401

	PO1	PO2	PO3	PO4	PO5	PO6
C401.1	3	3	3	3	3	3
C401.2	3	2	2	3	3	3
Average	3	2.5	2.5	3	3	3

CO-PSO mapping matrix for MEMT-401

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
C401.1	3	3	3	3	3	3
C401.2	3	3	3	3	3	3
Average	3	3	3	3	3	3

Progressive Seminar/Laboratory Development Work
MEMT-404

Max. Marks: 50
Total Credits: 02

Objectives :
The Progressive Seminar/Laboratory Development work provides an opportunity to students to present the work they executed during their dissertation in industries/organizations, physical laboratories and virtual laboratories such as computer-simulated modelling. The progressive seminar/laboratory learning provides opportunities for students to relate and strengthen the theoretical/practical concepts they learn.

Outcomes: Through seminars and lab development work, the students learn to:

CO1. Present their work including methods adopted, techniques learnt and practical competence acquired during the dissertation.
CO2. Enrich their knowledge/learning in emerging areas related to the subject.

CO-PO mapping matrix for course Progressive Seminar/Laboratory Development Work

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
C404.1	3	3	3	3	3	3
C404.2	2	2	2	3	2	3
Average	**2.5**	**2.5**	**2.5**	**3**	**2.5**	**3**

CO-PSO mapping matrix for course Progressive Seminar/Laboratory Development Work

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
C404.1	3	2	2	2	2	3
C404.2	3	3	3	2	2	3
Average	**3**	**2.5**	**2.5**	**2**	**2**	**3**

CO-PO-PSO mapping matrix for all the courses of M.Tech. (Energy and Environmental Management)

Course Code	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
C101	2.14	2.29	1.5	2	2.14	2.57	1.5	1.7	1.86	1.75	2.75	1.5
C102	1.5	1.67	-	2.33	1.5	2.17	1.7	2.7	1.5	2.2	1.6	2.0
C103	2.25	1.5	1.75	2.63	1.8	2.5	2.13	1.6	1.88	1.71	1.6	1.75
C104	2.5	2.5	1.67	2	2	2.83	1.5	1.5	2.17	1.5	1.5	2.5
C201	2.5	1.5	1.5	2.33	1.5	2.67	2.33	1.5	2.33	1.6	2.33	2.67
C202	2.4	-	1.5	2.5	1.5	2.5	2.33	2.33	1.7	2	2	2.33
C203	-	1.8	-	2.33	2	2.83	2.33	1.7	2.17	2.5	1.75	3
C204	2.67	1.5	2.25	2.33	2.5	2.67	2	2.5	1.67	2	1.75	3
C301EL1A	-	1.5	1.5	2.5	1.67	2.5	2.17	2.4	1.75	2.4	2.17	2
C301EL1B	2.8	2.6	1.6	2.0	2.4	2.8	2.2	1.5	2.5	2.2	1.6	2.2
C301EL1C	1.5	2	1.83	2.25	1.83	2.75	1.75	1.5	1.71	1.67	1.5	2.13
C302EL2A	2	2	1.7	2.5	1.8	2.8	1.83	1.5	1.5	2.17	2.17	2.17
C302EL2B	2.4	2.4	2	2.2	2.5	2.5	1.83	2	1.7	2.6	2.2	2.33
C302EL2C	2	1.6	2	2.6	2.6	2.8	2.2	2	2.2	1.8	1.5	2
C401	3	2.5	2.5	3	3	3	3	3	3	3	3	3
C404	2.5	2.5	2.5	3	2.5	3	3	2.5	2.5	2	2	3