MANIPAL UNIVERSITY
JAIPUR

INSPIRED BY LIFE

17 PARTNERSHIPS FOR THE GOALS

17.4.2 Education for SDGs: Specific Programs Courses on Sustainability

The Manipal University Jaipur is committed to providing relevant instruction centered on the SDGs throughout the university, in select programs, and in selected courses in specific programs.

Manipal University offers two programs: **M Tech in Environmental Engineering and M Tech in Non-Sewered Sanitation** in adherence to updated environmental laws and regulations for the development of megacities and the complicated difficulties associated with their hyper-growth. Governments and the public all over the world increasingly anticipate that modern organizations will become more ecologically responsible and take ideas like "Sustainability" and "Life cycle analysis" into consideration. The program offers a comprehensive program covering Wastewater Systems, Solid Waste Management, Waste Treatment Plants, Environmental Remote Sensing, Environmental Systems Modelling, Applied Transport Phenomena, Air Pollution Control Technologies, Environmental Statistics, Sanitation Technology, Environmental Ecology, Urban Environmental Quality Management, Energy, Environment and Climate Change, Leadership in Sanitation and more.

Manipal university also offers a degree in **Master of Architecture in Landscape** to deal with the issue of coexistence. Today, with the rapid growth of cities, sustainable landscape planning and design are a serious concern, because, within the urban context, green areas such as parks, gardens, green belts, and road reserves enable positive human interaction with nature, help maintain natural resources, and form environments that bring in wildlife, especially birds. During rapid urbanization and climate change, wildlife habitats have become indispensable components of the urban fabric and landscape of cities. Urbanization during the latter half of the twentieth century has altered habitats, restructured wildlife communities, and influenced the range sizes and population dynamics of animal species. The program offers Regional Ecology II, Landscape Morphology, Landscape Heritage Conservation, and Environment Laws & Legislations.

Manipal university Jaipur, **M Tech Energy Science and Technology** focused on the in-depth knowledge of various facets of energy. The focus of the program lies in the concept of power generation through a nonconventional route. As the reservoirs of the conventional form of energy such as coal & oil are on the brink of ending, the major portion of global energy requirement is to be met through alternate forms of energy such as solar, wind energy, biomass, etc. The alternate form of energy usage not only meets the major energy requirement but also addresses global emission concerns. The program connects the various forms of energy and their importance in our lives and for the development of our nation. This program is a unique multidisciplinary program with solutions for the energy crisis as well as an environmental concern.

MANIPAL UNIVERSITY
JAIPUR
(University under Section 2(f) of the UGC Act)

17 PARTNERSHIPS FOR THE GOALS

Manipal University Jaipur' Dedicated Courses Embracing Sustainability and the SDGs

Manipal University Jaipur has taken a progressive leap in addressing the pressing global challenges outlined by the Sustainable Development Goals (SDGs) by introducing dedicated courses focused on sustainability. These specialized academic offerings stand as a testament to higher education institutions' commitment to nurturing a generation of students equipped with the knowledge and skills to drive change towards a more sustainable world.

The integration of dedicated courses addressing sustainability and the SDGs represents a paradigm shift in academia. These courses cover a wide spectrum of disciplines, delving into environmental sustainability, social equity, economic development, responsible business practices, and governance for sustainable development. Their comprehensive nature offers students a holistic understanding of the interconnected challenges facing society. One of the significant advantages of these dedicated courses lies in their interdisciplinary approach. They encourage students from diverse academic backgrounds to explore and integrate sustainability principles within their respective fields. This integration fosters a nuanced understanding of how sustainability applies across various disciplines, from sciences and engineering to social sciences, business, and the arts.

Manipal University Jaipur offers students the opportunity to engage in hands-on experiences, including open elective courses, program elective courses, projects, internships, case studies, and fieldwork that address real-world sustainability challenges. The Outcome-based education empowers students to practice theoretical understanding into impactful action. Critical thinking and problem-solving skills stimulate innovative solutions to complex global challenges. The emphasis on developing analytical and problem-solving abilities allows students to approach sustainability issues creatively. This approach encourages the development of adaptive strategies and solutions that can address the diverse and evolving challenges faced in the pursuit of the SDGs.

SDG courses contribute to the development of future leaders committed to driving impactful change. By nurturing leadership qualities and instilling a sense of responsibility, they equip students with the capacity to drive sustainable initiatives and influence decision-making processes in their respective fields.

MANIPAL UNIVERSITY JAIPUR
Department of Civil Engineering
M Tech (Environmental Engineering)
Batch – 2021-2022

Year	FIRST SEMESTER						SECOND SEMESTER					
	Sub. Code	**Subject Name**	**L**	**T**	**P**	**C**	**Sub. Code**	**Subject Name**	**L**	**T**	**P**	**C**
I	CV6102	Air Pollution Monitoring and Control	3	1	0	4	CV6201	Environmental Impact Assessment	4	0	0	4
	CV6103	Water Treatment and Sanitation Systems	3	1	0	4	CV6202	Wastewater Treatment Systems	3	1	0	4
	CV6107	Energy, Environment and Climate Change	3	1	0	4	CV6203	Solid and Hazardous Waste Management	3	1	0	4
	CV61XX	Program Elective – I	3	0	0	3	CV62XX	Program Elective – II	4	0	0	4
	MA6104	Statistics, Probability and Reliability	3	1	0	4	CV62XX	Program Elective – III	4	0	0	4
	DR6001	Research Methodology	3	0	0	3	------	Open Elective	3	0	0	3
	CV6130	Environmental Engineering Lab - I	0	0	2	1	CV6230	Environmental Engineering Lab - II	0	0	2	1
	CV6180	Minor Project	0	0	2	1	CV6235	Seminar	0	0	2	1
							CV6280	Minor Project	0	0	2	1
			18	4	4	**24**			21	2	6	**26**
	Total Contact Hours (L + T + P)		26				Total Contact Hours (L + T + P) + OE		29			
IV	**THIRD AND FOURTH SEMESTER**											
	CV7080	Dissertation							0	0	0	25
							Total Contact Hours (L + T + P) + OE		0			

Program Elective – I		**Open Elective**	
Sub. Code	**Subject Name**	**Sub. Code**	**Subject Name**
CV6140	Environmental Ecology	CV6280	Environmental Management
CV6141	Urban Environmental Quality Management		
CV6144	Environmental Chemistry and Microbiology		
Program Elective – II			
CV6240	Environmental Economics and Management		
CV6241	Advanced Wastewater Treatment		
CV6242	Environmental Hydrology		
Program Elective – III			
CV6243	Mathematical Modelling in Environmental Engineering		
CV6244	Remote Sensing and GIS Applications		
CV6245	Risk Assessment and Disaster Management		
CV6246	Industrial Waste Management and Disposal		

MANIPAL UNIVERSITY JAIPUR

Syllabus for M.Tech. Environmental Engineering

First Semester

CV6102: AIR POLLUTION MONITORING AND CONTROL [3 1 0 4]

Introduction: Definition of Air Pollution, Global effects of air pollution, Air Pollution Episode, Sources and types of air pollutants, Effect of air pollutants on human beings, plants, animals and economic aspects. Air pollution control acts, ambient air quality standards, sampling and measurement of particular and gaseous pollutants. Air Quality Index. Meteorology: Environmental factors, Elemental properties of the atmosphere, plume dispersion, modelling, maximum mixing depth, stack design. Controlling of Air Pollution and controlling equipments. Gaseous pollutants – absorption, adsorption devices, combustion and condensation devices. Noise Pollution and Control: Sources & Effects, Kinetics of noise, Measurements and control, Noise standards and case studies.

References:

1. Noel de Nevers, *Air Pollution Control Engineering*, McGraw Hill, Inc. New York, 1995.
2. S. P. Mahajan, *Pollution Control in Process industries*, TMH Publishing Co., New Delhi, 2000.
3. A. C. Stern, *Air Pollution*, Academic Press, Inc. New York, 1991.
4. Howard S. Peavy, Donald R. Rowe, George Tchobanoglous, *Environmental Engineering*, McGraw Hill, Singapore, 1986.

CV6103: WATER TREATMENT AND SANITATION SYSTEMS [3 1 0 4]

Water Quality: Definitions and Concepts, Water sources, characteristics and water quality standards, Estimation of water quantity. Water Treatment: Theory and design of Conventional Unit Operations used in Water Treatment, Advanced Water Treatment: Theory and Design of Advanced Unit Operations used in Water Treatment: Membrane processes, Ion Exchange, Aeration/stripping, Precipitation, Adsorption, Oxidation-reduction and advanced oxidation processes; Methods of Low Cost Water Treatment, Water supply concept during emergencies. Water Quality Index (WQI), Basics of distribution system design. Sanitation Systems: Introduction, City wide sanitation planning, Types of Compendium. Sanitation products, functional group, Single and double pit technologies, Anaerobic sanitation technologies, Emerging sanitation technologies, Collection and Conveyance: Container and sewer based sanitation systems.

References:

1. L. D. Benefield, J. F. Judkins, B. L. Weand, *Process Chemistry for Water and Wastewater Treatment*, End ed., Prentice-Hall, Inc. New Jersey, USA, 1982.
2. V.M. Ehlers, E.W. Steel, *Municipal and Rural Sanitation*. New York: McGraw Hill Book Company, 1927.
3. C. Sawyer, P, McCarty and G. Parkin, *Chemistry for Environmental Engineering and Science*, 5/e, McGraw Hill, New Delhi, 2003.
4. Howard S. Peavy, Donald R. Rowe, George Tchobanoglous, *Environmental Engineering*, McGraw Hill, Singapore, 1986.

CV6107: ENERGY, ENVIRONMENT AND CLIMATE CHANGE [3 1 0 4]

Overview on the Earth's energy requirement vis-à-vis Climate Change. Origins of the terrestrial atmosphere. Earth's early atmosphere. Introduction to Climate. Layers of atmosphere. Composition of atmosphere. Atmospheric chemistry, greenhouse gases and O_3 depletion problem. Energy Balance: Earth –Atmosphere System. Solar and Terrestrial Radiation. Solar variability and the Earth's Energy Balance. Atmospheric Chemistry and Climate Change. Atmospheric Aerosol and Cloud Effects on Climate. Environmental Variability: Natural and Anthropogenic. Effects of urbanization, Landscape changes, Desertification and Deforestation. International Forums: Safeguarding Future Climate. The role of International Bodies. Kyoto and Montreal Protocol. Intergovernmental Panel on Climate Change (IPCC 2007). The Stern Report. Carbon Credits. Indian Context. Alternative Energy Sources: Solar, Wind, Hydro Power and Nuclear Energy. Predicting Future Climate Change: Global Climate Models.

References:

1. J. Jaeger, *Climate and Energy Systems - A review of their interactions*, John Wiley, 1983.
2. R. Wolfson, *Energy, Environment and Climate*, W. W. Norton & Co., Inc., New York, 2008.
3. W. R. Cotton, R. A. Pielke, *Human Impacts on Weather and Climate*, Cambridge University Press, 2007.
4. R.B. Stull, *Introduction to Boundary Layer Meteorology*, Reidel Publishing Co., Dordrecht, 1988.

MA6104: STATISTICS, PROBABILITY AND RELIABILITY [3 1 0 4]

Basics of Statistics: Random Variables and its Properties. Applications of Mean, Median, Mode, Standard Deviation, Correlation Coefficient in Analyzing Quality Related Data, Preliminary Analysis of

Data by Graphical Representation, Measure of Central Tendency Dispersion, Peakedness in Context with Construction Industry and Quality Control Problems, Dependent Variables, Co-Relation, Co-Relation Coefficient and It's Significance; Basic Probability: Probability of Discrete and Continuous Variables, Probability Mass Function, Probability Density Function, Cumulative Density Function, Discrete and Continuous Standard Probability Distributors and their Properties, Central Limit Theorem, Equivalent Normal Distribution for Non-Normal Distributions, Utilization of Random Events, Measures of Probability Concepts for Quality Control Related Issues, Applications of Frequency Distribution and Probability, Probability Distributors, Continuous And Discrete Distributions in Analyzing Data Related to Process and Quality Control, Goodness of Fit Tests, Chi-Square Test, Kolmogorov-Smirnov Goodness of Fit Test and Two Sample Test, Monte-Carlo Simulation; Reliability Analysis: Concept of Reliability, Risk and Safety Factors. Safety Margin Function, Reliability Index, FOSM Method of Reliability Analysis, Application of FOSM to Linear and Non Linear Safety Margin Functions-Hasofer-Lynd Method.

References:

1. L.T. Blank, *Statistical Procedures for Engineering, Management, and Science*, Mc-Graw Hill Series in Industrial Engineering and Management Science, 1982.
2. A.H.S. Ang, W.H. Tang, *Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering*, John Wiley & Sons; 2nd edition (2006)
3. N.T. Kottegoda, Rosso Renzo, Statistics, Probability and Reliability Methods for Civil and Environmental Engineers, McGraw-Hill College (1997).
4. W. Mendenhall, D. D. Wackerly, R. L. Scheaffer, *Mathematical Statistics with Applications*, 7th Edition, Thomson Brooks/Cole, 2008.
5. K. M. Ramachandran, C. P. Tsokos, *Mathematical Statistics with Applications*, Academic Press, 2009.

DR6001: RESEARCH METHODOLOGY [2 0 0 2]

Meaning of research, type of research, Qualitative and quantitative research, defining research problem, review of literature, formulation of theory & hypothesis, data collection, data analysis: hypothesis testing, ANOVA, regression analysis, reporting research findings. Design of experiments, Full and fractional factorial experiments, randomized block design, latin square design, robust design, taguchi method.

References:

1. C. R. Kothari, *Research methodology: methods and techniques*, New Age International Publication Ltd, 2018.
2. J. W. Creswell, *Research Design*, Sage South Asia Edition, 2009
3. D.G. Montgomery, *Design and Analysis of Experiments*, John Willy India Edition, 2016

CV6130: ENVIRONMENTAL ENGINEERING LABORATORY- I [0 0 2 1]

Analysis of water/wastewater for physicochemical parameters: Total solids, total dissolved solids, and volatile solids, Turbidity, alkalinity, pH, hardness, chlorides, sulphates, ammonical nitrogen, nitrates, sulphate, oil and grease, available chlorine, dissolve oxygen, biochemical oxygen demand, chemical oxygen demand. Residual chlorine and chlorine demand, determination of available chlorine in Bleaching powder, Determination of Calcium, Potassium, Sodium and Lithium. Determination of heavy metals in aqueous solution – Chromium, Lead and Zinc. Coagulation and flocculation of water – optimization of dose / pH / time of flocculation. Characteristics of Industrial wastewater. Analysis of solid wastes: characterisation of wastes from different industries.

References:

1. Standard Methods for the Examination of Water and Waste Water - ALPHA - AWWA – WPCF.
2. C. Sawyer, P. McCarty, G. Parkin, *Chemistry for Environmental Engineering,* McGraw Hill, New York. 1994.
3. IS: 3025 - 1964 - *Methods of Sampling and Test (Physical and Chemical) for Water Used in Industry*, IIT New Delhi.
4. Drinking water Standards IS: 10500-1991.

CV6180: MINOR PROJECT [0 0 2 1]

Students will undertake a project in the domains pertaining to relevant specialization

PROGRAM ELECTIVES – I

CV6140: ENVIRONMENTAL ECOLOGY [4 0 0 4]

Concepts & Fundamentals of ecology, Natural ecosystems and their food chains, food webs, bioenergetics, biochemical cycles and ecological succession. Ecological engineering principles, Biological diversity and its importance, reduction in biological diversity, Ecosystem Responses: Ecosystems responses to de-oxygenation nutrient enrichment, pesticides, hydrocarbons, metal and salts, thermal pollution, suspended solids and silt. Community Ecology: Principles of population and

community ecology, concepts of systems and models, building and analysis of models, environmental systems, structures and interaction between coastal aeolian, glacial, fluvial, weathering, soil and detrital systems. Integration Ecological Principles: Integration of classical, agro and restoration ecological principles and methods, Biomonitoring and its role in the evaluation of aquatic ecosystem, rehabilitation of ecosystem, Introductory models of ecosystems.

References:

1. E. P. Odum, G.W. Barrett, *Fundamentals of Ecology*, Thomson, 2002.
2. I. D. White, D. N. Mottershead, S. J. Harrison, *Environmental Systems: An Introductory Text*, Chapman and Hall, London, 1992.
3. P. A. Colinvaux, *Introduction to Ecology*, John Wiley & Sons, New York, 1973.

CV6141: URBAN ENVIRONMENTAL QUALITY MANAGEMENT [4 0 0 4]

Urbanisation & Pollution: Consequences of urbanization, Sources of pollution to the urban environment: Status of pollution levels in major cities, Air & Noise Pollution in Urban Environment: Sources, nature and effect of air pollution on Urban Environment. Air pollution Indices, Sources of noise pollution, Status and effect of noise pollution in major cities. Water and Land pollution in Urban Environment: Water demands and pollution in urban areas, Sources of land pollution in urban areas: Impact of urban soil pollution on quality of living system. Management of Urban Environment Quality: Land use planning – traffic management. Safe municipal water supply and planning of safe municipal water supply and drainage system, solid waste management including disposal, abatement of noise pollution, regulation of settlements. Natural Conservation: Planning of urbanization on ecological basis, preservation and development of green recovery areas. Urban Disaster Management: Management of Industrial explosions, landslides, earthquakes, Floods and Management of epidemics.

References:

1. C. K. Varshney, *Water Pollution and Management*, Wiley Eastern Ltd., New Delhi, 1998.
2. S. Plowden, *The Cost of Noise*, London, Metra, 1996.
3. A.B. Gallion, S. Eisner, *The Urban Pattern: City Planning and Design*, Van Nostrand, 1963.
4. M. J. Suess, S. R. Craxford, *Manual on urban air quality management*, WHO, Copenhagen, 1976

CV6144: ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY [3 1 0 4]

Importance of Environmental Chemistry, Types of reactions, Redox reactions, Reaction kinetics, Electrochemistry and its applications. Physical and equilibrium chemistry: fundamentals and applications. Trace Contaminants and their analyses, Buffers and Buffer index, Colloidal Chemistry: Properties of colloids, colloidal dispersions, stability of colloids and applications. Colourimetry: Principles and applications. Applications of Analytical Chemistry: emission and absorption techniques. Microbiology: Microorganisms in air, water and soil environment. Principle and applications of microscopy, microscopic flora and fauna, Metabolism and metabolic pathways, Bio-concentration, Bio-magnification and Bio-accumulation. Bacteria: Morphology, typical growth curve and generation time. Measurement Techniques: APC, MPN (Probability and Thomas methods), Enzymes classification, kinetics - Michaelis-Menten equation, factors influencing enzyme reaction.

References:

1. R. E. McKinney, *Microbiology for Sanitary Engineers*, New York McGraw Hill, 1962.
2. C. Sawyer, P, McCarty and G. Parkin, *Chemistry for Environmental Engineering and Science*, 5/e, McGraw Hill, New Delhi, 2003.
3. M. J. Pelczar, ECS Chan, N. R. Krieg, *Textbook of Microbiology,* 5e, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1998.
4. A. F. Gaudy, *Microbiology for Environmental Scientists and Engineers*, McGraw Hill, 1980.

Second Semester

CV6201: ENVIRONMENTAL IMPACT ASSESSMENT [4 0 0 4]

Concepts of EIA: Effect of human activity on environment, concept of eco-system imbalances, definition of EIA, EIS, EMP, industrial policy of the Govt. of India. Prediction and assessment of impacts on air, water, biota, noise, cultural and socio-economic environment, Air quality indices, air quality impact of industry transport systems, human settlements. Methods of assessment, litigation of impact. Water quality impact: Water quality criteria, standards and indices, Impacts on water quality of development projects. Biota: Impact on fauna and flora, mitigation measures, alternatives. Noise: Effects of noise on people, noise scales and rating methods. Estimating transportation noise impacts. Cultural and socio economic impacts: Effect of developmental projects on cultural and social settings and economic profile of the community. Energy impact: EIA of hydro, thermal and nuclear power plants. Methodologies for EIA: Preliminary assessment, quantification, comparison of alternatives and comprehensive EIAs

References:

1. L. W. Canter, *Environmental Impact Assessment*, (2e), McGraw-Hill, 1997.
2. Y. Anjaneyulu, V. Manickam, *Environmental Impact Assessment Methodologies*, CRC Press, 2011.
3. J. Petts, G. Eduljee, *Environmental Impact Assessment for Waste Treatment and Disposal Facilities*, John Wiley & Sons, 1994.
4. G. Burke, B. R. Singh, L. Theodore*, Handbook of Environmental Management and Technology*, (2e), John Wiley & Sons, 2004.

CV6202: WASTEWATER TREATMENT SYSTEMS [3 1 0 4]

Introduction: Objectives of treatment, wastewater characteristics, flow variations and hydraulic profile, types of reactors, CSTR and PFR reactors analysis. Wastewater Treatment: Types and basics working principles of treatment unit, Theoretical principles and design: Suspended growth and attached growth system, Designing and related kinetics of various wastewater treatment unit, Sludge Processing: Separation - sludge thickeners, volume reduction, conditioning and digestion – aerobic and anaerobic. Advanced Wastewater Treatment: Need and technologies used. Nitrification and Denitrification Processes, Phosphorous removal. Wastewater disinfection. Treatment and Disposal of wastewater: Compact, simple and low cost wastewater treatment units in rural areas; Effluent disposal. Integrated water resource management & health, Concept of Total sanitation, Sanitation under emergencies.

References:

1. A. R. N. Sankar, *Environmental Management*, Oxford University Press, New Delhi, 2015.
2. M. M. Sulphey, *Introduction to Environmental Management*, PHI Learning, New Delhi, 2013.
3. C. C. Lee, S.D. Lin, *Handbook of Environmental Engineering Calculations*, McGraw Hill, New York, 1999.
4. C. Sawyer, P, McCarty and G. Parkin, *Chemistry for Environmental Engineering and Science*, 5/e, McGraw Hill, New Delhi, 2003.

CV6203: SOLID AND HAZARDOUS WASTE MANAGEMENT [3 1 0 4]

Municipal Solid Waste Management: Legal and Organizational foundation: Definition, sources and types of solid waste, major legislation, monitoring responsibilities, sampling and characterization, storage and handling of solid waste. Collection and transport of solid waste: types of collection systems, analysis of collection system. Transport means and methods, transfer station types and design requirements. Process of Solid Waste and Energy recovery, Geo-environmental investigations, engineered sites, leachate control and treatment, gas recovery and control, including utilization of recovered gas (energy), and landfill monitoring and reclamation, Integrated waste management facilities. Economics of the on-site v/s off-site waste management options. Natural attenuation process and its mechanisms. Household Hazardous Waste Management: Definition and identification of hazardous wastes-sources and characteristics, Design practices. Hazardous waste regulations, handling, storage, collection and transport of hazardous waste..

References:

1. G. Tchobanoglous, F. Kreith, *Handbook of Solid Waste Management*, McGraw-Hill Education, 2002.
2. A. Bagchi, *Design, Construction, and Monitoring of Landfills*, Wiley Interscience, 1994.
3. G. Tchobanoglous,H. Theisen, S.A. Vigil, *Integrated Solid Waste Management: Engineering Principles and Management Issues*, McGraw- Hill Publication, 1993.
4. C. A. Wentz, *Hazardous Waste Management*, McGraw-Hill Publication, 1995.

CV6230: ENVIRONMENTAL ENGINEERING LABORATORY-II [0 0 2 1]

Determination of phenol compounds and total/ kjeldhal nitrogen in wastewater, Determination of total phosphate, sulphate of the given sample, Settling-column analysis, Microscopic examination of micro-organisms, Plate count test, MPN count-total and faecal, Sampling and analysis of inorganic and organic substances. Ambient air quality monitoring: Determination of PM10, PM2.5, SO_x, NO_x, CO. Demonstration of stack monitoring. Measurement of noise pollution. Use of analytical instrument such as AAS, Gas Chromatography, LC for gas and micro-pollutant analysis

References:

1. Standard Methods for the Examination of Water and Waste Water - ALPHA - AWWA – WPCF.
2. C. Sawyer, P. McCarty, G. Parkin, *Chemistry for Environmental Engineering,* McGraw Hill, New York. 1994.
3. IS: 3025, *Methods of Sampling and Test (Physical and Chemical) for Water Used in Industry*, IIT New Delhi, 1964.

CV6235: SEMINAR [0 0 2 1]

Students will present a seminar on topic related to relevant specialization.

CV6280: MINOR PROJECT [0 0 2 1]

Students will undertake a project in the domains pertaining to relevant specialization.

PROGRAM ELECTIVES – II

CV6240: ENVIRONMENTAL ECONOMICS AND MANAGEMENT [4 0 0 4]

Sustainable Development: Introduction to sustainable development, Economy-Environment inter-linkages, Environmental Kuznets curve, Economics of energy, scarcity, optimal resources, backstop technology. Economic significance, causes and analysis of environmental degradation, Concepts of policy failure, Equi-marginal principle. Economics of Pollution, regulation, monitoring and enforcement, managing pollution using existing markets: Bargaining solutions, Cost-benefit analysis, Concept of Total Economic Value, Alternative approaches. Economics of biodiversity, Policy responses at national and international levels. Economics of Climate Change.

References:

1. D. W. Pearce, A. Markandya, E. B. Barbier, *Blueprint for a Green Economy*, Earthscan, London, 1989.
2. D. W. Pearce, R. K. Turner, I. Bateman, *Environmental Economics: An Elementary Introduction*, Harvester Wheatsheaft, London, 1994.
3. D.W. Pearce, R. K. Turner, *Economics of Natural Resources and the Environment*, Harvester Wheatsheaf, London, 1990.
4. Michael S. Common, Michael Stuart, *Environmental and Resource Economics: An Introduction*, 2nd Edition, Harlow: Longman, 1996.

CV6241: ADVANCED WASTEWATER TREATMENT [4 0 0 4]

Importance of Advanced Wastewater Treatment, Basis of process selection and development of treatment flow sheets. Biological nutrient removal process, conventional biological nitrification/ denitrification processes and its process fundamentals. Sequencing Batch Reactor (SBR) and Simultaneous Nitrification – Denitrification (SND) processes. Membrane Bio-Reactor for removal of organic pollutants and suspended solids, Other new treatment technologies Physical and chemical treatment methods, Removal of phosphorus by chemical addition. Refractory Organics and Dissolved Inorganic Substances Removal: Advanced Oxidation Processes (AOP)/ Adsorption / Chemical precipitation / Ion Exchange / Membrane Processes. Wastewater Reclamation/Reuse/Disposal: Direct and indirect reuse of wastewater- Municipal reuse/industrial reuse/agricultural reuse/ recreational reuse/ground water recharge. Criteria and disposal of effluent in to lakes, rivers and ocean.

References:

1. A. R. N. Sankar, *Environmental Management*, Oxford University Press, New Delhi, 2015.
2. M. M. Sulphey, *Introduction to Environmental Management*, PHI Learning, New Delhi, 2013.
3. C. C. Lee, S.D. Lin, *Handbook of Environmental Engineering Calculations*, McGraw Hill, New York, 1999.
4. C. Sawyer, P, McCarty and G. Parkin, *Chemistry for Environmental Engineering and Science*, 5/e, McGraw Hill, New Delhi, 2003.

CV6242: ENVIRONMENTAL HYDROLOGY [4 0 0 4]

Concepts of Hydrology: definition, scope and role of environmental hydrology. Types of data, sources, River hydrology, catchment, waterways, water-shed, Surface water characteristics, Ground water occurrence, types of aquifers, Environmental Influences, fluctuation due to evapotranspiration, meteorological effect of tides, recharge. Ground Water Pollution: Quality analysis, sources of pollution monitoring quality, sea water intrusion, and preventive measures. Ground Water Modelling: contamination modelling, flow modelling, transport modelling, Accuracy of models, Application of Numerical methods, Modelling of subsurface transport of microorganisms, Hydrological Consequences: Eco-hydrological consequences of Environmental degradation water conservation, planning and impact process, mitigation of impact processes.

References:

1. P. V. Singh, *Environmental Hydrology*, Kluver Academic Publishers, London, 1997.
2. D. K. Todd, *Ground water Hydrology*, John Willy Sons, New York, 2004.
3. H. Nash, G. J. H. McCall, *Ground water Quality*, Chapman & Hall Publishers, London, 1995.
4. H. M. Raghunath, *Ground water*, Willy and Eastern publication, New York, 1987.
5. Ray K. Linsley, Joseph B. Franzini, *Water Resource Engineering*, Mc Graw Publications, New York, 1987.

PROGRAM ELECTIVES – III

CV6243: MATHEMATICAL MODELLING IN ENVIRONMENTAL ENGINEERING [4 0 0 4]

Basics and Necessity of Modelling, Earth's atmosphere, Lapse Rate Quantification, stability states, Quantification of wind circulation and geo-strophic winds. Material Mass-Energy flows balances, Air Pollution Modelling, Boundary Layer: mixing length and eddy diffusion, Gaussian Plume Model. Plume Rise estimation. Simple noise quality models: Models for Roadway Noise, Modelling the mass transport of Sulphur Dioxide into falling rain drops. Reaction Pathways. Mass and Charge Balance. Normalization of the Convective Diffusion Equation. Modelling the Homogeneous and Heterogeneous Pathways for Ozone depletion. Global Warming and Climate Change Modelling: Solar and Terrestrial Radiation. Quantifying the Green House Effect. A model for estimating the Equilibrium temperature of the Earth. Aerosol and cloud processes. The Basic tenets of Global Circulation Models for Weather Forecasting, Water Quality Modelling, Solid waste modelling, Modelling the methane potential of discards.

References:

1. J. Smith, P. Smith, *Introduction to Environmental Modelling*, OUP, 2009.
2. G. M., Master, *Introduction to Environmental Engineering and Science*' Prentice-Hall of India, New Delhi, 3rd Edition, 2007.
3. H.S. Peavy, D.R. Rowe, G. Tchobanoglous, *Environmental Engineering*, McGraw-Hill Book Company, New York. 1985.
4. R.B. Stull, *Introduction to Boundary Layer Meteorology*, Reidel Publishing Co., Dordrecht, 1988.

CV6244: REMOTE SENSING AND GIS APPLICTIONS [4 0 0 4]

Basics of Remote Sensing: Introduction to remote sensing, Electromagnetic radiation, Characteristic of real remote sensing systems, Satellite - Indian remote sensing satellite Sensors and Retrievals. Image interpretation & Processing: Elements and concept of image interpretation, Basics of GIS: Introduction to GIS, History of development of GIS, Elements of GIS, Computer hardware and software, GIS Analysis: Map overlay, Vector and raster data model, Mapping concept, Data storage and database management, Development of map overlay, Overlay operation, Applications of GIS and remote sensing in Energy & Environmental Engineering.

References:

1. A. N. Patel, S. Singh, *Remote Sensing Principles and Applications*, Scientific Publisher, Jodpur, 1999.
2. P. A. Burrough, *Principle of Geographical Information Systems for Land Resources Assessment*, Clarendon Press, Oxford, 2000.
3. T. M. Lilles, R. W. Kiefer, *Remote Sensing and Image Interpretation*, John Wiley & Sons, New York, 1999.
4. K.C. Clarke, B.O. Parks, M.P. Crane, *Geographic Information Systems and Environmental Modeling*, Prentice-Hall of India, 2005.

CV6245: RISK MANAGEMENT AND DISASTER MANAGEMENT [4 0 0 4]

Risk Assessment: Methodologies and Guidelines: Principles, Code of practice, Emergency plans, Occupational Health and Safety, Risk analysis survey and health evaluation, behavioural studies, epidemiological approach, Risk assessment techniques, Risk Assessment and Disaster Response, Quantification Techniques, NGO Management, SWOT Analysis based on Design & Formulation Strategies, Insurance & Risk Management. Disaster Management: Introduction & Dimensions of Natural & Anthropogenic Disasters, Principles/Components of Disaster Management, Role of Union/States, Armed Forces/Other Agencies in Disasters, Role of Financial Institutions in Mitigation Effort, Concept of Team Building, Motivation Theories and Applications, School Awareness and Safety Programs, Psychological and Social Dimensions in Disasters, Trauma and Stress, Emotional Intelligence, Electronic Warning Systems. Use of Information systems, Experiences and case studies.

References:

1. V. K. Rao, *Environmental Strategics Hand book*, Mc-graw Hill Inc., New York, 1994.
2. W. B. Neely, G. E. Blan, *Environmental Exposure from chemicals*, Volume II, CHC Press Inc., Florida, 1989.
3. W. E. Woodsen, *Human factors design handbook – information and guidelines for design to systems, facilities, equipment and product for human use*, Mc Graw Hill, New York, 1981.

CV6246: INDUSTRIAL WASTE MANAGEMENT AND DISPOSAL [4 0 0 4]

Introduction: Industrial scenario in India, Sources, types and disposal of Industrial wastewater, Regulatory requirements, generation rates, characterization and variables, Individual and Common Effluent Treatment Plant, Cleaner production: Waste management approach, Waste audit, Material and process modifications, Zero discharge processes- case studies. Treatment and Disposal of industrial effluents, Treatment and disposal of solid wastes: Sources and quantities of solid waste from industrial processes, Waste classification, Residuals of industrial wastewater treatment, Case studies.

References:

1. W. W. Eckenfelder, *Industrial Water Pollution Control*, Mc-Graw Hill, 1999.
2. L. N. Nelson, *Liquid waste of Industry, Theories, Practice and Treatment,* Addison-Wesley Publishing Company, London, 2000.

3. World Bank Group, *Pollution Prevention and Abatement Handbook – Towards Cleaner Production*, World Bank and UNEP, Washington D.C., 1998.
4. R. L Stephenson, J. B. Blackburn, *Industrial Wastewater Systems Handbook*, Lewis Publishers, New York, 1998.

OPEN ELECTIVE

CV6280: Environmental Management [3 0 0 3]

Environmental Economics: Introduction, Economic Tools for Evaluation, Cleaner Development Mechanisms (CDM) and their Applications; Environmental Laws and Policies: Water Act, Air Act, Environment Protection Acts, Solid Waste Management Rules, Hazardous and Biomedical Waste Rules; Environmental Audit: Methods, Procedure, Reporting and Case Studies; Environmental Management System and Techniques: Environmental Safety and ISO 14000 Standards, ISO 14001 Standards, Environmental Management Systems, (EMS) Total Quality Management (TQM) and Total Safety Management (TSM), ISO 9000 and ISO 18000 Standards.

References:

1. A. R. N. Sankar, *Environmental Management*, Oxford University Press, New Delhi, 2015.
2. M. M. Sulphey, *Introduction to Environmental Management*, PHI Learning, New Delhi, 2013.
3. MOEF, Government of India, "*Carrying Capacity Based Developmental Planning Studies for the National Capital Region"*, 1995-96.
4. *Environmental Laws* - MOEF, Government of India.

Third and Fourth Semester

CV7080: DISSERATION [0 0 0 25]

Students will undertake a project in the domains pertaining to relevant specialization.

MANIPAL UNIVERSITY JAIPUR
Department of Civil Engineering
M Tech (Non Sewered Sanitation)
Batch – 2021-2022

Year	FIRST SEMESTER						SECOND SEMESTER					
	Sub. Code	**Subject Name**	**L**	**T**	**P**	**C**	**Sub. Code**	**Subject Name**	**L**	**T**	**P**	**C**
I	CV6104	Sanitation Technology	3	1	0	4	CV6204	Emergency Sanitation	4	0	0	4
	CV6105	Sanitation Flow Analysis	3	1	0	4	CV6205	Project Management	3	1	0	4
	CV6106	Sanitation and Public Health	3	1	0	4	CV6206	Sanitation Behaviour and Advocacy	3	1	0	4
	CV61XX	Program Elective – I	3	0	0	3	CV62XX	Program Elective – II	4	0	0	4
	MA6104	Statistics, Probability and Reliability	3	1	0	4	CV62XX	Program Elective – III	4	0	0	4
	DR6001	Research Methodology	3	0	0	3	------	Open Elective	3	0	0	3
	CV6130	Environmental Engineering Lab - I	0	0	2	1	CV6230	Environmental Engineering Lab - II	0	0	2	1
	CV6180	Minor Project	0	0	2	1	CV6235	Seminar	0	0	2	1
							CV6280	Minor Project	0	0	2	1
			18	4	4	**24**			21	2	6	**26**
	Total Contact Hours (L + T + P)		26				Total Contact Hours (L + T + P) + OE		29			
IV	**THIRD AND FOURTH SEMESTER**											
	CV7080	Dissertation							0	0	0	25
							Total Contact Hours (L + T + P) + OE		0			

Program Elective – I		**Open Elective**	
Sub. Code	**Subject Name**	**Sub. Code**	**Subject Name**
CV6140	Environmental Ecology	CV6290	Sanitation Financing
CV6141	Urban Environmental Quality Management		
CV6142	Energy, Environment and Climate Change		
CV6143	Leadership in Sanitation		
Program Elective – II			
CV6240	Environmental Economics and Management		
CV6241	Advanced Wastewater Treatment		
CV6242	Environmental Hydrology		
CV6248	Sanitation Governance		
Program Elective – III			
CV6243	Mathematical Modelling in Environmental Engineering		
CV6244	Remote Sensing and GIS Applications		
CV6245	Risk Assessment and Disaster Management		
CV6246	Industrial Waste Management and Disposal		
CV6247	Research Theory & Practices		

MANIPAL UNIVERSITY JAIPUR

Syllabus of M. Tech. Non Sewered Sanitation

FIRST SEMESTER

CV6104: SANITATION TECHNOLOGY [3 1 0 4]

Introduction to types of onsite sanitation system – Introduction to different type of user interface, Types of containment system, Treatment mechanism of onsite sanitation system Twin pit latrine, septic tanks etc. Determination of Qualities and Quantities (Q&Q) of FS. Innovation in treatment technology such as solar septic tank, tiger toilet etc. Onsite sanitation treatment technologies :- Carbon, nitrogen and phosphorus removal & recovery; sludge treatment, Case Studies in Sanitation, Faecal sludge treatment technologies, Innovation processes, collection and transport, Introduction to Urban Drainage and Sewerage.

References

1. Elizabeth Tilley, Lukas Ulrich, Christoph Lüthi,Philippe Reymond, Roland Schertenleib and Christian Zurbrügg. *Compendium of*
2. *Sanitation Systems and Technologies*. Eawag,IEEE, Vancouver: IWA Publishing, 2016.
3. Ligon, David M robbins and Grant C. *How to design wastewater systems for local conditions in developing countries*. London SW1H 0QS, UK: IWA publishing, 2014.
4. Linda Strande, Mariska Ronteltap, Damir Brdjanovic. *Faecal Sludge Management: Systems Approach for Implementation and Operation*. London SW1H 0QS, UK: IWA Publishing, 2014.
5. Miriam Englund, Linda Strande. *Faecal Sludge Management: Highlights and Exercises*. Switerzland: IWA publishing, 2019.
6. Organisation, World Health. *Guidelines on Sanitation and Health*. Geneva: World Health Organisation, 2018. English.
7. Shubhra Singh, Riya Rachel Mohan etal. "Technology options for faecal sludge management in developing countries: Benefits and revenue from reuse." *Environmental Technology & Innovation* (2017).

CV6105: SANITATION FLOW ANALYSIS [3 1 0 4]

Analysis of sanitation streams, Details of Solid in sludges , measure of organic and inorganic in FS, determination of quantity of faeces and urine, parameters tested should include chemical, physical and biological, Classification of waste types, Current legislation, Introduction to sanitation streams as a raw material, Introduction to FSSM policy India and Implementation status, Analysis using Shit Flow Diagram, Review of potential Laboratory - Review of pollution and health issues associated with sanitation streams, Sanitation streams and typical characteristics.

References

1. Development, Ministry of Urban. *National Policy on Faecal Sludge & Septage Management*. National Policy. New Delhi: Government of India, 2017.
2. Linda Strande, Mariska Ronteltap, Damir Brdjanovic. *Faecal Sludge Management: Systems Approach for Implementation and Operation*. London SW1H 0QS, UK: IWA Publishing, 2014.
3. Miriam Englund, Linda Strande. *Faecal Sludge Management: Highlights and Exercises*. Switerzland: IWA publishing, 2019.
4. Organisation, World Health. *Guidelines on Sanitation and Health*. Geneva: World Health Organisation, 2018. English.
5. Suresh Kumar Rohilla, CSE, Bhitush Luthra, CSE. *SFD Promotion and Initiative* . Annual Report. Delhi: Centre of Science & Environment , 2016. English.

CV6106: SANITATION AND PUBLIC HEALTH [3 1 0 4]

Biological characteristics and lifecycles of sanitation-relevant pathogens – Introduction, human health hazards related to excreta, pathogens and transmission routes associated with human excreta, non-infectious health issues related to sanitation, and control measures to protect public health Control Measures, Human Health Hazards and Human Excreta – enteric infection and its impact. Introduction to Public Health – Child Undernutrition , Non-infectious Public Health Issues Related to Sanitation, Review and Assessment of Transmission Routes, Risk Evaluation Tools.

References

1. Development, Ministry of Urban. *National Policy on Faecal Sludge & Septage Management*. National Policy. New Delhi: Government of India, 2017.
2. Elizabeth Tilley, Lukas Ulrich, Christoph Lüthi,Philippe Reymond, Roland Schertenleib and Christian Zurbrügg. *Compendium of Sanitation Systems and Technologies*. Eawag,IEEE, Vancouver: IWA Publishing, 2016.
3. Linda Strande, Mariska Ronteltap, Damir Brdjanovic. *Faecal Sludge Management: Systems Approach for Implementation and Operation*. London SW1H 0QS, UK: IWA Publishi
4. ng, 2014.
5. Organisation, World Health. *Guidelines on Sanitation and Health*. Geneva: World Health Organisation, 2018. English.

MA6104: STATISTICS, PROBABILITY AND RELIABILITY [3 0 0 3]

Basics of Statistics: Random Variables and its Properties. Applications of Mean, Median, Mode, Standard Deviation, Correlation Coefficient in Analyzing Quality Related Data, Preliminary Analysis of Data by Graphical Representation, Measure of Central Tendency Dispersion, Peakedness in Context with Construction Industry and Quality Control Problems, Dependent Variables, Co-Relation, Co-Relation Coefficient and It's Significance; Basic Probability: Probability of Discrete and Continuous Variables, Probability Mass Function, Probability Density Function, Cumulative Density Function, Discrete and Continuous Standard Probability Distributors and their Properties, Central Limit Theorem, Equivalent Normal Distribution for Non-Normal Distributions, Utilization of Random Events, Measures of Probability Concepts for Quality Control Related Issues, Applications of Frequency Distribution and Probability, Probability Distributors, Continuous And Discrete Distributions in Analyzing Data Related to Process and Quality Control, Goodness of Fit Tests, Chi-Square Test, Kolmogorov-Smirnov Goodness of Fit Test and Two Sample Test, Monte-Carlo Simulation; Reliability Analysis: Concept of Reliability, Risk and Safety Factors. Safety Margin Function, Reliability Index, FOSM Method of Reliability Analysis, Application of FOSM to Linear and Non Linear Safety Margin Functions-Hasofer-Lynd Method.

References:

1. B. Leland, "*Stastical Procedure for Engineering, Management and Science*", Mc-Graw Hill Series in Industrial Engineering and Management Science, 1982.

2. T. Angand , "*Probability Concepts in Engineering Planning and Design"*, Vol. I and II, Wiley International, 1984.

3. N.T. Kottegoda, R. Rosso, "*Statistics, Probability and Reliability for Civil and Environmental Engineers"*, Mc-Graw Hill International, 1998.

4. D.D. Wackerly, W. Mendenhall and R. L. Scheaffer, "*Mathematical Statistics with Applications"*, 7th Edition, Thomson Brooks Cole, 2008.

5. K.M. Ramachandran, C.P. Tsokos, *"Mathematical Statistics with Applications*", Academic Press, 2009.

DR6001: RESEARCH METHODOLOGY [3 0 0 3]

Research: Meaning, Definitions, & Purpose of Research, Review of Literature, Problem Formulation (How to Select a Topic for Research), Research Proposal, Variables, Hypothesis, Objectives of Research Topic, Population; Sampling: Meaning & Types; Data: Types, Techniques - Characteristics of a Good Test, Classification, Tabulation & Graphical Re-Presentations & Coding of Data, Use of SPSS Software; Analysis of Data: Mean, Median, Mode, Correlation, Regression, Normal Distribution, Hypothesis Testing, Report Writing; *Thesis Writing And Journal Publication: Writing Thesis, Writing Journal and Conference Papers, IEEE and Harvard Styles of Referencing, Effective Presentation, Copyrights, and Avoiding Plagiarism.

References:

1. Cooper D.R., Schindler P.S., *"Business Research Methods"*, Tata McGraw Hill Publication, New Delhi.
2. Kothari C.R., "*Research Methodology Methods and Techniques*", New Age International Publication, New Delhi, 2006.
3. Sharma K.R., "*Operational Research & Quantitative Techniques*", Kalyani Publications,
4. Kapoor V.K., "*Operational Research*", Sultan Chand & Co.
5. Creswel J.W., "*Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*", SAGE, 2004.
6. Beat John W., Kahn James V., "*Research in Education*", 10th Edition, Eastern Economy Edition, PHI Leaning Pvt. Ltd. New Delhi.
7. Wagner W.E. III, IBM, "*SPSS Statistics*", 4th Edition, SAGE Publication.Com.
8. Khan A.J., Raeside R., White D., "*Research Methods for Graduate Business & Social Sciences Students*", Response Book, Business Books from SAGE, New Delhi.

CV6130: ENVIRONMENTAL ENGINEERING LAB – I [0 0 2 1]

Analysis of water/wastewater for physicochemical parameters: Total solids, total dissolved solids, and volatile solids, Turbidity, alkalinity, pH, hardness, chlorides, sulphates, ammonical nitrogen, nitrates, sulphate, oil and grease, available chlorine, dissolve oxygen, biochemical oxygen demand, chemical oxygen demand. Residual chlorine and chlorine demand, determination of available chlorine in Bleaching powder, Determination of Calcium, Potassium, Sodium and Lithium. Determination of heavy metals in aqueous solution – Chromium, Lead and Zinc. Coagulation and flocculation of water – optimization of dose / pH / time of flocculation. Characteristics of Industrial wastewater. Analysis of solid wastes: characterisation of wastes from different industries.

References:

1. Standard Methods for the Examination of Water and Waste Water - ALPHA - AWWA – WPCF.
2. C. Sawyer, P. McCarty, G. Parkin, *Chemistry for Environmental Engineering*, McGraw Hill, New York. 1994.
3. IS: 3025 - 1964 - Methods of Sampling and Test (Physical and Chemical) for Water Used in Industry, IIT New Delhi.
4. Drinking water Standards IS: 10500-1991.

CV6180: MINOR PROJECT [0 0 2 1]

Students will undertake a project in the domains pertaining to relevant specialization

SECOND SEMESTER

CV6204: EMERGENCY SANITATION [4 0 0 4]

Development of a sanitation plan, Humanitarian contexts; Humanitarian reform and standards; Cluster approach, Humanitarism; History of humanitarian action; Humanitarian principles and dilemma's; Code of conduct and guiding principles of humanitarian action, Identification of key diseases in emergencies and their link to the Bradley classification; Vectors of importance in emergencies related to excreta and solid waste; Case study: vector control, Introduction to the WASH cluster; SPHERE standards, Key excreta disposal, collection, transportation and treatment options; Adaptability; Cultural and behavioural aspects; Inclusiveness and inter-sectoral considerations; Putting planning into practice , Needs assessment; Monitoring and evaluation , Solid waste management standards and planning; Health-care waste management concepts and technologies , The legal framework; International Relief System; Key actors in humanitarian relief.

References

1. Cross, group of NGOs and the Red. *The Humanitarian Charter and Minimum Standards in Humanitarian Response*. Hampshire, United Kingdom: The Sphere Project, 2011. Handbook.

2. Elizabeth Tilley, Lukas Ulrich, Christoph Lüthi,Philippe Reymond, Roland Schertenleib and Christian Zurbrügg. *Compendium of Sanitation Systems and Technologies*. Eawag,IEEE, Vancouver: IWA Publishing, 2016.

3. Linda Strande, Mariska Ronteltap, Damir Brdjanovic. *Faecal Sludge Management: Systems Approach for Implementation and Operation*. London SW1H 0QS, UK: IWA Publishing, 2014.

4. Organisation, World Health. *Guidelines on Sanitation and Health*. Geneva: World Health Organisation, 2018. English.

CV6205: PROJECT MANAGEMENT [3 1 0 4]

Context analysis, Finalize project plan, Good practices and criteria for good project proposals**,** Indicators for project implementation and operation, Indicators for validation of results/impact, Introduction to case study and group assignment, Key elements of project planning, Monitoring, evaluation and learning (MEL) frameworks/Monitoring for Results vs Implementation, MS Project, Options Analyses, Multi-Criteria Analyses, Problem analysis, Project Human Resources, Project management cycle, Project plan to implementation plan, Project Planning Software, Recap/Transfer Exercise of previously developed project plan, Resource disposition, Results-based Project Management, Risk assessment and mitigation, Stakeholder analysis, Stakeholder management, Task Planning and Work Breakdown Structure (WBS), Theory of Change - Assumptions and justifications, Map Conditions, select a path of change

References

1. Basyal, Isha. "Faecal Sludge Management Toolbox." 2017. Document.

2. Cross, group of NGOs and the Red. *The Humanitarian Charter and Minimum Standards in Humanitarian Response*. Hampshire, United Kingdom: The Sphere Project, 2011. Handbook.

3. Elizabeth Tilley, Lukas Ulrich, Christoph Lüthi,Philippe Reymond, Roland Schertenleib and Christian Zurbrügg. *Compendium of Sanitation Systems and Technologies*. Eawag,IEEE, Vancouver: IWA Publishing, 2016.

4. Linda Strande, Mariska Ronteltap, Damir Brdjanovic. *Faecal Sludge Management: Systems Approach for Implementation and Operation*. London SW1H 0QS, UK: IWA Publishing, 2014.

5. Miriam Englund, Linda Strande. *Faecal Sludge Management: Highlights and Exercises*. Switerzland: IWA publishing, 2019.

6. Organisation, World Health. *Guidelines on Sanitation and Health*. Geneva: World Health Organisation, 2018. English.

CV6206: BEHAVIOUR CHANGE & ADVOCACY [3 1 0 4]

Behaviour: Definitions & concepts; & Change & advocacy Sanitation & behaviour change: Actors and behaviour across the sanitation chain; Evolution and current thinking in urban sanitation programming; & Behaviour change strategies - Promoting change via persuasion & policy vs education/awareness raising, Behaviour change frameworks, Behaviour change intervention design, Occupational health & safety, Community-Led Total Sanitation (CLTS), Public policy & behaviour, Media & advocacy, Sanitation, behaviour change & advocacy

References

1. D.J. Barringtona, b,c,∗, S. Sridharana,1, K.F. Shieldsd,2, S.G. Saundersa,3, R.T. Souterb,4, J. Bartramd,2. "Sanitation marketing: A systematic review and theoretical critique using the capability approach." *Social Science & Medicine* (2017): 128-134. Research Paper.
2. Development, Ministry of Urban. *National Policy on Faecal Sludge & Septage Management*. National Policy. New Delhi: Government of India, 2017.
3. Elizabeth Tilley, Lukas Ulrich, Christoph Lüthi,Philippe Reymond, Roland Schertenleib and Christian Zurbrügg. *Compendium of Sanitation Systems and Technologies*. Eawag,IEEE, Vancouver: IWA Publishing, 2016.
4. Linda Strande, Mariska Ronteltap, Damir Brdjanovic. *Faecal Sludge Management: Systems Approach for Implementation and Operation*. London SW1H 0QS, UK: IWA Publishing, 2014.
5. Miriam Englund, Linda Strande. *Faecal Sludge Management: Highlights and Exercises*. Switerzland: IWA publishing, 2019.
6. Organisation, World Health. *Guidelines on Sanitation and Health*. Geneva: World Health Organisation, 2018. English.

CV6230: ENVIRONMENTAL ENGINEERING LAB – II [0 0 2 1]

Determination of phenol compounds and total/ kjeldhal nitrogen in wastewater, Determination of total phosphate, sulphate of the given sample, Settling-column analysis, Microscopic examination of microorganisms, Plate count test, MPN count-total and faecal, Sampling and analysis of inorganic and organic substances. Ambient air quality monitoring: Determination of PM10, PM2.5, SOx, NOx, CO. Demonstration of stack monitoring. Measurement of noise pollution. Use of analytical instrument such as AAS, Gas Chromatography, LC for gas and micro-pollutant analysis

References

1. Standard Methods for the Examination of Water and Waste Water - ALPHA - AWWA – WPCF.
2. Sawyer C. McCarty P. and, Parkin G., *Chemistry for Environmental Engineering,* McGraw Hill, New York. 1994.
3. IS - 3025 - 1964 - *Methods of Sampling and Test (Physical and Chemical) for Water Used in Industry*, IIT New Delhi.

CV6235: SEMINAR [0 0 2 1]

Students will present a seminar on topic related to relevant specialization.

CV6280: MINOR PROJECT [0 0 2 1]

Students will undertake a project in the domains pertaining to relevant specialization.

PROGRAMME ELECTIVES-I

CV6140: ENVIRONMENTAL ECOLOGY [3 0 0 3]

Concepts & Fundamentals of ecology, Natural ecosystems and their food chains, food webs, bioenergetics, biochemical cycles and ecological succession. Ecological engineering principles, Biological diversity and its importance, reduction in biological diversity, Ecosystem Responses: Ecosystems responses to de-oxygenation nutrient enrichment, pesticides, hydrocarbons, metal and salts, thermal pollution, suspended solids and silt. Community Ecology: Principles of population and community ecology, concepts of systems and models, building and analysis of models, environmental systems, structures and interaction between coastal aeolian, glacial, fluvial, weathering, soil and detrital systems. Integration Ecological Principles: Integration of classical, agro and restoration ecological principles and methods, Biomonitoring and its role in the evaluation of aquatic ecosystem, rehabilitation of ecosystem, Introductory models of ecosystems.

References:

1. E. P. Odum, G.W. Barrett, *Fundamentals of Ecology*, Thomson, 2002.
2. I. D. White, D. N. Mottershead, S. J. Harrison, *Environmental Systems: An Introductory Text*, Chapman and Hall, London, 1992.
3. P. A. Colinvaux, *Introduction to Ecology*, John Wiley & Sons, New York, 1973.

CV6141: URBAN ENVIRONMENTAL QUALITY MANAGEMENT [3 0 0 3]

Urbanisation & Pollution: Consequences of urbanization, Sources of pollution to the urban environment: Status of pollution levels in major cities, Air & Noise Pollution in Urban Environment: Sources, nature and effect of air pollution on Urban Environment. Air pollution Indices, Sources of noise pollution, Status and effect of noise pollution in major cities. Water and Land pollution in Urban Environment: Water demands and pollution in urban areas, Sources of land pollution in urban areas: Impact of urban soil pollution on quality of living system. Management of Urban Environment Quality: Land use planning – traffic management. Safe municipal water supply and planning of safe municipal water supply and drainage system, solid waste management including disposal, abatement of noise pollution, regulation of settlements. Natural Conservation: Planning of urbanization on ecological basis, preservation and development of green recovery areas. Urban Disaster Management: Management of Industrial explosions, landslides, earthquakes, Floods and Management of epidemics.

References:

1. C. K. Varshney, *Water Pollution and Management*, Wiley Eastern Ltd., New Delhi, 1998.
2. S. Plowden, *The Cost of Noise*, London, Metra, 1996.
3. A.B. Gallion, S. Eisner, *The Urban Pattern: City Planning and Design*, Van Nostrand, 1963.
4. M. J. Suess, S. R. Craxford, *Manual on urban air quality management*, WHO, Copenhagen, 1976

CV6142: ENERGY, ENVIRONMENT AND CLIMATE CHANGE [3 0 0 3]

Overview on the Earth's energy requirement vis-à-vis Climate Change. Origins of the terrestrial atmosphere. Earth's early atmosphere. Introduction to Climate. Layers of atmosphere. Composition of atmosphere. Atmospheric chemistry, greenhouse gases and O3 depletion problem. Energy Balance: Earth –Atmosphere System. Solar and Terrestrial Radiation. Solar variability and the Earth's Energy Balance. Atmospheric Chemistry and Climate Change. Atmospheric Aerosol and Cloud Effects on Climate. Environmental Variability: Natural and Anthropogenic. Effects of urbanization, Landscape changes, Desertification and Deforestation. International Forums: Safeguarding Future Climate. The role of International Bodies. Kyoto and Montreal Protocol. Intergovernmental Panel on Climate Change (IPCC 2007). The Stern Report. Carbon Credits. Indian Context. Alternative Energy Sources: Solar, Wind, Hydro Power and Nuclear Energy. Predicting Future Climate Change: Global Climate Models.

References:

1. J. Jaeger, *Climate and Energy Systems - A review of their interactions*, John Wiley, 1983.
2. R. Wolfson, Energy, *Environment and Climate*, W. W. Norton & Co., Inc., New York, 2008.
3. W. R. Cotton, R. A. Pielke, *Human Impacts on Weather and Climate*, Cambridge University Press, 2007.
4. R.B. Stull, *Introduction to Boundary Layer Meteorology*, Reidel Publishing Co., Dordrecht, 1988.

CV6143: LEADERSHIP IN SANITATION [3 0 0 3]

Concepts of leader, leadership, and management, Change Management and Theory of Change. 70:20:10 rule in leadership development, negotiation in wash projects, role of vision and strategy in wash intervention, conesus buiilding and conflict management in wash projects – source of confluict, structure, systems, culture and individuals. concept of emotional intelliginece and components of e motional intelligence. Individual leadership development plan for wash related project.

References

1. André TaylorA, Wouter T. Lincklaen ArriënsB and Matthew LaingC. "Understanding Six Water Leadership Roles: A Framework to Help Build Leadership Capacity." *Water Policy & Practice* (2015): 4-31. Journal Paper.
2. Cross, group of NGOs and the Red. *The Humanitarian Charter and Minimum Standards in Humanitarian Response*. Hampshire, United Kingdom: The Sphere Project, 2011. Handbook.
3. David V. Day a, ∗, John W. Fleenor b, Leanne E. Atwater. "Advances in leader and leadership development: A review of 25 years of research and theory." *The Leadership Quarterly* (2013): 63-82.
4. Development, Ministry of Urban. *National Policy on Faecal Sludge & Septage Management*. National Policy. New Delhi: Government of India, 2017.
5. Linda Strande, Mariska Ronteltap, Damir Brdjanovic. *Faecal Sludge Management: Systems Approach for Implementation and Operation*. London SW1H 0QS, UK: IWA Publishing, 2014.
6. Miriam Englund, Linda Strande. *Faecal Sludge Management: Highlights and Exercises*. Switerzland: IWA publishing, 2019.

PROGRAMME ELECTIVES-II

CV6240: ENVIRONMENTAL ECONOMICS AND MANAGEMENT [4 0 0 4]

Sustainable Development: Introduction to sustainable development, Economy-Environment inter-linkages, Environmental Kuznets curve, Economics of energy, scarcity, optimal resources, backstop technology. Economic significance, causes and analysis of environmental degradation, Concepts of policy failure, Equi-marginal principle. Economics of Pollution, regulation, monitoring and enforcement, managing pollution using existing markets: Bargaining solutions, Cost-benefit analysis, Concept of Total Economic Value, Alternative approaches. Economics of biodiversity, Policy responses at national and international levels. Economics of Climate Change.

References:

1. D. W. Pearce, A. Markandya, E. B. Barbier, *Blueprint for a Green Economy*, Earthscan, London, 1989.
2. D. W. Pearce, R. K. Turner, I. Bateman, *Environmental Economics: An Elementary Introduction*, Harvester Wheatsheaft, London, 1994.
3. D.W. Pearce, R. K. Turner, *Economics of Natural Resources and the Environment*, Harvester Wheatsheaf, London, 1990.
4. Michael S. Common, Michael Stuart, *Environmental and Resource Economics: An Introduction*, 2nd Edition, Harlow: Longman, 1996.

CV6241: ADVANCED WASTEWATER TREATMENT [4 0 0 4]

Importance of Advanced Wastewater Treatment, Basis of process selection and development of treatment flow sheets. Biological nutrient removal process, conventional biological nitrification/ denitrification processes and its process fundamentals. Sequencing Batch Reactor (SBR) and Simultaneous Nitrification – Denitrification (SND) processes. Membrane Bio-Reactor for removal of organic pollutants and suspended solids, Other new treatment technologies Physical and chemical treatment methods, Removal of phosphorus by chemical addition. Refractory Organics and Dissolved Inorganic Substances Removal: Advanced Oxidation Processes (AOP)/ Adsorption / Chemical precipitation / Ion Exchange / Membrane Processes. Wastewater

Reclamation/Reuse/Disposal: Direct and indirect reuse of wastewater- Municipal reuse/industrial reuse/agricultural reuse/ recreational reuse/ground water recharge. Criteria and disposal of effluent in to lakes, rivers and ocean.

References:

1. A. R. N. Sankar, *Environmental Management*, Oxford University Press, New Delhi, 2015.
2. M. M. Sulphey, *Introduction to Environmental Management*, PHI Learning, New Delhi, 2013.
3. C. C. Lee, S.D. Lin, *Handbook of Environmental Engineering Calculations*, McGraw Hill, New York, 1999.
4. C. Sawyer, P, McCarty and G. Parkin, *Chemistry for Environmental Engineering and Science*, 5/e, McGraw Hill, New Delhi, 2003.

CV6242: ENVIRONMENTAL HYDROLOGY [4 0 0 4]

Concepts of Hydrology: definition, scope and role of environmental hydrology. Types of data, sources, River hydrology, catchment, waterways, water-shed, Surface water characteristics, Ground water occurrence, types of aquifers, Environmental Influences, fluctuation due to evapotranspiration, meteorological effect of tides, recharge. Ground Water Pollution: Quality analysis, sources of pollution monitoring quality, sea water intrusion, and preventive measures. Ground Water Modelling: contamination modelling, flow modelling, transport modelling, Accuracy of models, Application of Numerical methods, Modelling of subsurface transport of microorganisms, Hydrological Consequences: Eco-hydrological consequences of Environmental degradation water conservation, planning and impact process, mitigation of impact processes.

References:

1. P. V. Singh, *Environmental Hydrology*, Kluver Academic Publishers, London, 1997.
2. D. K. Todd, *Ground water Hydrology*, John Willy Sons, New York, 2004.
3. H. Nash, G. J. H. McCall, *Ground water Quality*, Chapman & Hall Publishers, London, 1995.
4. H. M. Raghunath, *Ground water*, Willy and Eastern publication, New York, 1987.
5. Ray K. Linsley, Joseph B. Franzini, *Water Resource Engineering*, Mc Graw Publications, New York, 1987.

CV6248: SANITATION GOVERNANCE [4 0 0 4]

Introduction to governance - regulatory frameworks around the world– how is sanitation managed: where, how and why, Contextualizing sanitation: the politics of urban waste, sanitation from different perspectives, Formal and informal regulation, regulatory impact assessment, Governance alternatives amongst the “crisis of imagination”, Power relations among actors in the local and global levels: Gender, class & race relations and power asymmetries, Practices of coordination & decision making around contested water distribution, Sanitation history. What does history have to do with all this? : Sanitation in colonial contexts, Sanitation history. What does history have to do with all this? : Sanitation in Europe main cities, Shifting sanitation governance in light of justice concerns, The different actors and decision making processes, Water & sanitation governance: definitions, debates, controversies

References

1. D.J. Barringtona, b,c,∗, S. Sridharana,1, K.F. Shieldsd,2, S.G. Saundersa,3, R.T. Souterb,4, J. Bartramd,2. "Sanitation marketing: A systematic review and theoretical critique using the capability approach." *Social Science & Medicine* (2017): 128-134. Research Paper.
2. Development, Ministry of Urban. *National Policy on Faecal Sludge & Septage Management*. National Policy. New Delhi: Government of India, 2017.

3. Elizabeth Tilley, Lukas Ulrich, Christoph Lüthi,Philippe Reymond, Roland Schertenleib and Christian Zurbrügg. *Compendium of Sanitation Systems and Technologies*. Eawag,IEEE, Vancouver: IWA Publishing, 2016.

4. GUERRERO, TATIANA ACEVEDO. "A tale of an unequal city: Delhi's waters through the eyes of women working as domestic workers." *A tale of an unequal city: Delhi's waters through the eyes of women working as domestic workers* 23 03 2017.

5. Linda Strande, Mariska Ronteltap, Damir Brdjanovic. *Faecal Sludge Management: Systems Approach for Implementation and Operation*. London SW1H 0QS, UK: IWA Publishing, 2014.

6. Organisation, World Health. *Guidelines on Sanitation and Health*. Geneva: World Health Organisation, 2018. English.

7. Vidal, Cecilia Alda. *Connecting cultures, practices and sanitary systems, a case study from urban SSA/Malawi*. Manchester: cecilia.aldavidal@postgrad.manchester.ac.uk, 2017.

PROGRAM ELECTIEVES – III

CV6243: MATHEMATICAL MODELLING IN ENVIRONMENTAL ENGINEERING [4 0 0 4]

Basics and Necessity of Modelling, Earth's atmosphere, Lapse Rate Quantification, stability states, Quantification of wind circulation and geo-strophic winds. Material Mass-Energy flows balances, Air Pollution Modelling, Boundary Layer: mixing length and eddy diffusion, Gaussian Plume Model. Plume Rise estimation. Simple noise quality models: Models for Roadway Noise, Modelling the mass transport of Sulphur Dioxide into falling rain drops. Reaction Pathways. Mass and Charge Balance. Normalization of the Convective Diffusion Equation. Modelling the Homogeneous and Heterogeneous Pathways for Ozone depletion. Global Warming and Climate Change Modelling: Solar and Terrestrial Radiation. Quantifying the Green House Effect. A model for estimating the Equilibrium temperature of the Earth. Aerosol and cloud processes. The Basic tenets of Global Circulation Models for Weather Forecasting, Water Quality Modelling, Solid waste modelling, Modelling the methane potential of discards.

References:

1. J. Smith, P. Smith, *Introduction to Environmental* Modelling, OUP, 2009.

2. G. M., Master, *Introduction to Environmental Engineering and Science'* Prentice-Hall of India, New Delhi, 3rd Edition, 2007.

3. H.S. Peavy, D.R. Rowe, G. Tchobanoglous, *Environmental Engineering*, McGraw-Hill Book Company, New York. 1985.

4. R.B. Stull, *Introduction to Boundary Layer Meteorology*, Reidel Publishing Co., Dordrecht, 1988.

CV6244: REMOTE SENSING AND GIS APPLICTIONS [4 0 0 4]

Basics of Remote Sensing: Introduction to remote sensing, Electromagnetic radiation, Characteristic of real remote sensing systems, Satellite - Indian remote sensing satellite Sensors and Retrievals. Image interpretation & Processing: Elements and concept of image interpretation, Basics of GIS: Introduction to GIS, History of development of GIS, Elements of GIS, Computer hardware and software, GIS Analysis: Map overlay, Vector and raster data model, Mapping concept, Data storage and database management, Development of map overlay, Overlay operation, Applications of GIS and remote sensing in Energy & Environmental Engineering.

References:

1. A. N. Patel, S. Singh, *Remote Sensing Principles and Applications*, Scientific Publisher, Jodpur, 1999.

2. P. A. Burrough, *Principle of Geographical Information Systems for Land Resources Assessment*, Clarendon Press, Oxford, 2000.

3. T. M. Lilles, R. W. Kiefer, *Remote Sensing and Image Interpretation,* John Wiley & Sons, New York, 1999.

4. K.C. Clarke, B.O. Parks, M.P. Crane, *Geographic Information Systems and Environmental Modeling*, Prentice-Hall of India, 2005.

CV6245: RISK MANAGEMENT AND DISASTER MANAGEMENT [4 0 0 4]

Risk Assessment: Methodologies and Guidelines: Principles, Code of practice, Emergency plans, Occupational Health and Safety, Risk analysis survey and health evaluation, behavioural studies, epidemiological approach, Risk assessment techniques, Risk Assessment and Disaster Response, Quantification Techniques, NGO Management, SWOT Analysis based on Design & Formulation Strategies, Insurance & Risk Management. Disaster Management: Introduction & Dimensions of Natural & Anthropogenic Disasters, Principles/Components of Disaster Management, Role of Union/States, Armed Forces/Other Agencies in Disasters, Role of Financial Institutions in Mitigation Effort, Concept of Team Building, Motivation Theories and Applications, School Awareness and Safety Programs, Psychological and Social Dimensions in Disasters, Trauma and Stress, Emotional Intelligence, Electronic Warning Systems. Use of Information systems, Experiences and case studies.

References:

1. V. K. Rao, *Environmental Strategics Hand book*, Mc-graw Hill Inc., New York, 1994.

2. W. B. Neely, G. E. Blan, *Environmental Exposure from chemicals*, Volume II, CHC Press Inc., Florida, 1989.

3. W. E. Woodsen, H*uman factors design handbook – information and guidelines for design to systems, facilities, equipment and product for human use*, Mc Graw Hill, New York, 1981.

CV6246: INDUSTRIAL WASTE MANAGEMENT AND DISPOSAL [4 0 0 4]

Introduction: Industrial scenario in India, Sources, types and disposal of Industrial wastewater, Regulatory requirements, generation rates, characterization and variables, Individual and Common Effluent Treatment Plant, Cleaner production: Waste management approach, Waste audit, Material and process modifications, Zero discharge processes- case studies. Treatment and Disposal of industrial effluents, Treatment and disposal of solid wastes: Sources and quantities of solid waste from industrial processes, Waste classification, Residuals of industrial wastewater treatment, Case studies.

References:

1. W. W. Eckenfelder, *Industrial Water Pollution Control*, Mc-Graw Hill, 1999.

2. L. N. Nelson, *Liquid waste of Industry, Theories, Practice and Treatment*, Addison-Wesley Publishing Company, London, 2000.

3. World Bank Group, Pollution *Prevention and Abatement Handbook – Towards Cleaner Production*, World Bank and UNEP, Washington D.C., 1998.

4. R. L Stephenson, J. B. Blackburn, *Industrial Wastewater Systems Handbook*, Lewis Publishers, New York, 1998.

CV6247: RESEARCH THEORY & PRACTICES [4 0 0 4]

Critical Reading and Academic writing- Discourse markers, paraphrasing and plagiarism, Ethics in research and consent, Introduction to research portfolio, proposal template instruction, Presentation skills, Referencing guidelines- Plagiarism awareness and basics of literature search, Research - Training on specialised tools according to research needs, Research proposal defence, Field research, Data analysis, Thesis writing, Thesis defence.

References

1. BMGF. "Gender and The Sanitation Value Chain: A review of evidence." 2018. Report.
2. Borja-Vega, Luis Andres Christian. "Overview and Meta-Analysis of Global Water, Sanitation, and Hygiene (WASH) Impact Evaluations." *Water Global Practice* (2018): 1-34. Working Paper.
3. D.J. Barringtona, b,c,∗, S. Sridharana,1, K.F. Shieldsd,2, S.G. Saundersa,3, R.T. Souterb,4, J. Bartramd,2. "Sanitation marketing: A systematic review and theoretical critique using the capability approach." *Social Science & Medicine* (2017): 128-134. Research Paper.
4. DOUCET, ANDREA. *FEMINIST METHODOLOGIES AND EPISTEMOLOGY*. Carleton University, Canada: Carleton University, Canada, 2006. Book.

OPEN ELECTIVE

CV6290: SANITATION FINANCING [3 0 0 3]

Business canvas, Business models in sanitation, Financial Flow in business model, FSM Technical and Financial Assessment Tool, Innovative financing for sanitation, National context - sanitation financing: decentralisation and local authority finances, Overview of sanitation financing, Public Private Partnership (PPP) in sanitation, Saniplan Tool - financing model, Sanitation financing - modalities and challenges, Sanitation service and value chain, Sustainability in sanitation

References

1. Linda Strande, Mariska Ronteltap, Damir Brdjanovic. *Faecal Sludge Management: Systems Approach for Implementation and Operation*. London SW1H 0QS, UK: IWA Publishing, 2014.
2. Miriam Englund, Linda Strande. *Faecal Sludge Management: Highlights and Exercises*. Switerzland: IWA publishing, 2019.
3. Organisation, World Health. *Guidelines on Sanitation and Health*. Geneva: World Health Organisation, 2018. English.

Third and Fourth Semester

CV7080: DISSERATION [0 0 0 25]

Students will undertake a project in the domains pertaining to relevant specialization.

CURRICULUM & SCHEME OF EXAMINATION 2019-20

M Arch: Two Years Program

Applicable from Academic Session 2019-20

Year	Course Code	Course Name	L/S	T	P	C
First	**First Semester**					
	AR 6101	Landscape Design & Communication I	10	0	0	**10**
	AR 6102	Regional Ecology I	2	2	0	**4**
	AR 6103	Site Planning and Landscape Engineering	4	0	0	**4**
	AR 6104	History of Indian Landscape	2	1	0	**3**
	AR 6105	Landscape Morphology	2	1	0	**3**
	AR 61XX	Elective I	2	1	0	**3**
	Total		**22**	**5**	**5**	**27**
Second	**Course Code**	**Course Name**	**L/S**	**T**	**P**	**C**
	Third Semester					
	AR 7101	Professional Training & Pre Thesis	-	-	-	10
	Total		**-**	**-**	**-**	**10**

Course Code	Course Name	L/S	T	P	C
Second Semester					
AR 6201	Landscape Design & Communication II	10	0	0	**10**
AR 6202	Regional Ecology II	2	2	0	**4**
AR 6203	Planting Design	4	0	0	**4**
AR 6204	History of International Landscape	2	1	0	**3**
AR 6205	Research in Landscape	2	1	0	**3**
AR 62XX	Elective II	2	1	0	**3**
Total		**22**	**5**	**0**	**27**
Course Code	**Course Name**	**L/S**	**T**	**P**	**C**
Fourth Semester					
AR 7201	Thesis	20	0	0	20
AR 7202	Networks and systems in Landscape Architecture	2	1	0	**3**
AR 7203	Environment Laws & Legislations	3	1	0	**4**
Total		**25**	**2**	**0**	**27**

Electives offered as part of First (AR 61XX) and Second (AR 62XX) Semester of M Arch

Elective I (AR 61XX)		Elective II (AR 62XX)	
AR 6140	Landscape Heritage Conservation	AR 6240	Landscape Performance Evaluation
AR 6141	Settlement History and Development	AR 6241	Understanding Indian Landscape through Visual Arts

(Scheme i.e. applicable for batch 2021 onwards)

DEPARTMENT OF MECHANICAL ENGINEERING

MANIPAL UNIVERSITY JAIPUR

M. Tech. in Energy Science and Technology (EST)

Year	FIRST SEMESTER						Relative Weightage					SECOND SEMESTER						Relative Weightage				
	Sub. Code	Subject Name	L	T	P	C	CWS	PRS	MTE	ETE	PRE	Sub. Code	Subject Name	L	T	P	C	CWS	PRS	MTE	ETE	PRE
I	MA6101	Applied Numerical Analysis	3	1	0	4	20	-	40	40	-	ME6207	Energy Audit	3	1	0	4	20	-	40	40	-
	ME6170	Research Methodology	3	0	0	3	20	-	40	40	-	ME6208	Measurement & Control in Energy Systems	3	1	0	4	20	-	40	40	-
	ME6107	Non-Conventional Energy Sources	3	1	0	4	20	-	40	40	-	ME6209	Energy Economics	3	1	0	4	20	-	40	40	-
	ME6108	Thermal Science and Engineering	3	1	0	4	20	-	40	40	-	ME62XX	Program Elective II	3	0	0	3	20	-	40	40	-
	ME6109	Energy Storage	3	1	0	4	20	-	40	40	-	ME62XX	Program Elective III	3	0	0	3	20	-	40	40	-
	ME61XX	Program Elective I	3	0	0	3	20	-	40	40	-	*** ****	Open Elective	3	0	0	3	20	-	40	40	-
	ME6132	Energy Lab-1	0	0	4	2	-	60	-	-	40	ME6232	Energy Lab-2	0	0	4	2	-	60	-	-	40
												ME6233	Energy Simulation Lab	0	0	4	2	-	60	-	-	40
												ME6270	Seminar	0	0	2	1		-	-	-	-
			18	4	4	24								18	3	10	26					
	Total Contact Hours (L + T + P)		26									Total Contact Hours (L + T + P) + OE		28+ 3 = 31								
II											THIRD & FOURTH SEMESTER											
	ME7070	Dissertation												0	0	0	25	-	-	25	75	-
											Total Contact Hours (L + T + P) + OE			0								

Program Electives-I	Program Electives-II	Program Electives-III	Open Elective:
ME6144: Alternative Fuels ME6145: Carbon Audit and Management ME6146: Solar Energy Applications ME6147: Energy Conversion & Storage	ME6247: Electrical Energy Technology and Management ME6248: Fundamentals of Solar Photovoltaics ME6249: Waste to Energy ME6250: Energy, Environment and Climate Change	ME6251: Biomass gasification & pyrolysis ME6252: Biomass Conversion and Biorefinery ME6253: Wind and Hydro Energy Systems	ME6280: Lean and Agile Manufacturing ME6281: Industrial Safety

DEPARTMENT OF MECHANICAL ENGINEERING
MANIPAL UNIVERSITY JAIPUR

M. Tech. in ENERGY SCIENCE AND TECHNOLOGY (EST)

MA6101: APPLIED NUMERICAL ANALYSIS [3 1 0 4]
Mathematical modeling and engineering problem solving: simple mathematical model, conservation laws and engineering. Approximations and round of errors: Accuracy and precision, error definitions, round off errors, truncation errors and Taylor's series. Roots of equations: Bracketing methods, open methods, roots of polynomials applied to engineering problems. Linear algebraic equations: LU decomposition and matrix inversion, special matrices and Gauss Seidel applied to engineering problems. Numerical Differentiation and Integration: Newton Cotes Integration formulas, integration of equations, numerical differentiation applied to engineering problems. Ordinary Differential Equations: RK methods, Boundary value and Eigen value problems. Partial Differential Equations: Finite difference method for elliptic and parabolic equation applied to engineering problems.

References:

1. S.C. Chapra and R.P. Canale, *Numerical Methods for Engineers*, McGraw Hill Publication, 1998.
2. S.S. Sastry, *Numerical Analysis for Engineers*, McGraw Hill Publication, 2002

ME6170: RESEARCH METHODOLOGY [3 0 0 3]
Mathematical tools for analysis, statistical analysis of data, regression analysis, correlation, concept of best fit and exact fit – Lagrange interpolation, Newton divided difference, least square regression. Design of experiment definition, objective, factorial design, designing engineering experiments, ANOVA, Fractional, Full and Orthogonal Experiments, Taguchi methods for robust design, response surface methodology. Engineering Optimization definition, basics of nonlinear optimization, formulation of optimization problems-examples, Calculus techniques- Lagrange multiplier method – examples, nature inspired optimization techniques i.e. GA, PSO, SA etc., neural network-based optimization, optimization using fuzzy systems. Sampling Techniques: basic terms, Importance of sampling in research, essentials of a good sample, sampling error, standard error of the mean (Standard Deviation), Estimation of parameters, accuracy & precision of estimation, sampling procedure, types/methods of sampling, Central limit theorem, sample size determination, confidence interval and Confidence level. Measurement & Scaling Techniques: - types of data: Primary & Secondary, Types of Scales: Ratio, Interval, Ordinal Nominal. Mapping rules, characteristics of a good measurement, sources of error in measurement. Mathematical modeling of Engineering systems Basic concepts of modeling of Engineering systems – Static and dynamic model – Model for prediction and its limitations, system simulation using tools like MATLAB, SPSS, Minitab, COMSOL, Ansys etc.- validation, use of optimization techniques – Genetic Algorithm, Simulated Annealing. Design of Experiments: Basic principles, Study of completely randomized and randomized block design.

Reference:

1. C R Kothari, *Research Methodology: methods and techniques*, New Age International Publication Ltd
2. J W Creswell, *Research Design*, Sage South Asia Edition
3. D G Montgomery, *Design and analysis of Experiments*, John Willy India Edition
4. Stuart Melville and Wayne guddard, *Research Methodology an introduction for Science & Engineering Students*.
5. Ganesen MJP Publishers, Research Methodology for Engineers, Chennai, 201.

ME6107: NON-CONVENTIONAL ENERGY SOURCES [3 1 0 4]
Introduction: Concepts of pollution and climate change, Sources of environmental pollution. Renewable energy sources: Solar energy, Calculation of solar radiation on horizontal and inclined surfaces, Measurement of solar radiation, Low temperature applications. Solar distillation, Heat pump, Solar refrigerator, Passive space conditioning, Solar thermal power generation, Photovoltaic. Wind energy, Physical and thermo-chemical methods of bioconversion, Biological methods. Hydropower Energy: Present status of hydro power, magneto-hydro-dynamic (MHD) energy conversion. Ocean energy resources, Ocean wave energy conversion and tidal energy conversion. Geothermal Energy: Types of

geothermal energy sites, Geothermal power plants. Nuclear Energy. Conversion of energy: Thermal, chemical, and electromagnetic energy into electricity. Renewable energy economics.

References:

1. S. P. Sukatme and J. Nayak, *Solar Energy Principles of Thermal Collection and Storage*, (3e), Tata Mc Graw Hill, 2008.
2. G. D. Rai, *Non-Conventional Energy Sources*, Khanna Publications, 2011.
3. H. P. Garg and J. Prakash, *Solar Energy: Fundamentals and Applications*, (1e) McGraw Hill Education, 2017.
4. S. Rao and Dr. B B Parulekar, *Energy Technology*, Khanna Publishers, 2004.
5. B. H. Khan, *Non-Conventional Energy Resources*, (3e), McGraw Hill Education India Private Limited, 2017.

ME6108: THERMAL SCIENCE AND ENGINEERING [3 1 0 4]

Introduction: Energy and entropy balances, Equilibrium criteria. Laws of thermodynamics and cycles: Entropy, Thermodynamics power cycles. Conduction heat transfer: Basic concepts of Conduction, Heat diffusion equations, Heat transfer laws, Heat transfer through wall, cylinder, sphere, Optimum thickness of insulation, Conduction with heat source, Unsteady state heat transfer. Convection heat transfer: Boundary layers concept, Dimensionless numbers, Various equations related to heat transfer during laminar and turbulent flow for flat plate as well as pipe flow, Convection with phase change. Condensation and boiling. Radiation heat transfer: Radiation heat transfer basic laws, Shape factor, Shape factor calculations for different bodies, Radiations exchange between surfaces. Heat exchangers and evaporators: LMTD, Effectiveness-NTU methods.

References:

1. P.K. Nag PK, *Engineering Thermodynamics*, (6e), McGraw Hill Education, 2008.
2. Boles M. A. and Cengel Y. A., *Thermodynamics: An Engineering Approach*, (8e) McGraw-Hill Education, 2017.
3. White F. M., *Fluid Mechanics*, (8e), McGraw-Hill Education, 2015.
4. F. P. Incropera, D. P. Dewitt, T. I. Bergman and A. S. Lavine, *Fundamentals of Heat and Mass Transfer*, (6e), John Wiley & Sons, 2006.

ME6109: ENERGY STORAGE [3 1 0 4]

Need for energy storage, Different modes of energy storage. Potential energy, Pumped hydro storage, KE and Compressed gas system, Flywheel storage, Compressed air energy storage, Electrical and magnetic energy storage, Capacitors, Electromagnets, and Battery storage systems. Chemical Energy storage, Thermo-chemical, Photochemical, Bio-chemical, Electrochemical, Fossil fuels and Synthetic fuels and Hydrogen storage. Laid Acid Battery, Proton exchange membrane Fuel cell/Microbial Fuel cell. SHS mediums, Stratified storage systems, Rock-bed storage systems, Thermal storage in buildings, Earth storage, Energy storage in aquifers, Heat storage in SHS systems, Aquifers storage Phase Change Materials (PCMs), Selection criteria of PCMs, Stefen problem, Solar thermal LHTES systems, Energy conservation through LHTES systems, LHTES systems in refrigeration and air-conditioning systems. Enthalpy formulation, Numerical heat transfer in melting and freezing process. Food preservation, Waste heat recovery, Solar energy storage.

References:

1. L.F. Cabeza, *Advances in Thermal Energy Storage Systems: Methods and Applications*, (2e), Woodhead Publishing, UK, 2020.
2. S. Kalaiselvam, and R. Parameshwaram, *Thermal Energy Storage for Sustainability-Systems Design, Assessment and Applications,* Academic Press Inc. 2014.
3. S. P. Sukhame and J P Nayak, *Solar Energy: Principles of Thermal Collection and Storage,* (3e) Tata McGraw Hill, 2008.
4. Harald Mehling and Luisa F. Cabeza, *Heat and Cold Storage with PCM*, Springer-Verlag Berlin Heidelberg, 2008.

ME6207: ENERGY AUDIT [3 1 0 4]

Energy audit concepts: Energy needs of growing economy, Long term energy scenario, Energy pricing, Energy sector reforms. Energy security, Energy strategy for the future, Energy conservation Act-2001 and its features. Energy Codes And Standards. Measurements: Mass and energy balances: Facility as an energy system, Methods for preparing process flow, Material, and energy balance diagrams. Financial Management: Investment-need, Appraisal and criteria, Financial analysis techniques- Simple payback period, Return on investment, Net present value, Internal rate of return, Cash flows, Risk and sensitivity analysis, Financing options, Energy performance contracts and role of ESCOs. Electricity tariff, Load management, Power factor improvement, Distribution, and transformer losses. Losses in induction motors, Motor efficiency, Factors affecting motor performance, Rewinding and motor replacement issues, Energy efficient motors, Light source, Choice of lighting, Luminance requirements, and Energy conservation avenues. Compressed air system: Types of air compressors, Compressor efficiency, Efficient compressor operation.

References:

1. Y.P. Abbi, and S. Jain, *Handbook on Energy Audit and Environment Management*, The Energy and Resources Institute, 2009.
2. Frank Kreith and D. Yogi Goswami, *Introduction to Energy Conservation and Management*, CRC Press, 2017.
3. Paul O'Callaghan, *Energy Management*, McGraw-Hill Education.
4. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, *Energy Management Handbook*, (7e), CRC Press, 2011.

ME6208: MEASUREMENT & CONTROL IN ENERGY SYSTEMS [3 1 0 4]

Introduction: Basic measurement concepts, Measurement errors, Calibration, Uncertainty analysis. Thermo-flow measurement: Pressure, Velocity, Force, Temperature, Thermal radiation, Heat flux, Humidity. Measurement of Flow: Flow visualization techniques, Shadowgraph, Schlieren and interferometer. Temperature Measurement: Different principles of temperature measurement, Measurement of heat flux, Calibration of temperature measuring instruments. Air pollution sampling and measurement of particulates, SO_x, NO_x, CO, O_3, Hydrocarbons. Measurement of wind speed, Wind direction. Solar irradiance, Controls of solar and wind energy systems.

References:

1. S.P. Venkatesan, *Mechanical Measurement*, (2e), Ane Books Pvt. Ltd, 2015.
2. Karl B. Schnelle, Jr., Russell F. Dunn, Mary Ellen Terne, *Air Pollution Control Technology Handbook*, CRC Press, 2002 (Indian Reprint: 2014).
3. J.P. Holman, *Experimental Methods for Engineers*, 8th Edition, McGraw-Hill Education, (2011).
4. J. Billingsley, *Essentials of Control Techniques and Theory*, CRC Press, 2009.

ME6209: ENERGY ECONOMICS [3 1 0 4]

System economics: Sector wise consumption of energy resources, Electricity-fuel-transportation, Energy Scenario and supply position of different energy sectors: Indian and international Level – Coal, Oil, Natural Gas, RE, Hydro, Nuclear, Simple payback period, IRR, NPV, Life cycle costing, Cost of saved energy, Cost of energy generated. Energy demand forecasting: Forecasting, Simple and advanced techniques, Econometric approach to energy demand forecasting, Input-output model, Scenario based approach, ANN based approach, Hybrid approach, Energy demand analysis. Economics of demand/load management: Demand side management, cost effectiveness of DSM, Introduction to DSM, concept of DSM, Benefits of DSM, different techniques of DSM, Methods of DSM Load control, DSM planning.

References:

1. Subhes C. Bhattacharyya. *Energy Economics: Concepts, Issues, Markets and Governance.* Springer Science & Business Media, 2011.

2. T.C. Kandpal, *Financial Evaluation of Renewable Energy Technologies*, Macmillan Publishers India, 2003.
3. Peter Zweifel, Aaron Praktiknjo, and Georg Erdmann, *Energy Economics: Theory and Applications*, Springer-Verlag Berlin Heidelberg, 2017.
4. Aris Spanos, *Statistical Foundations of Econometric Modelling*, Cambridge University Press. 2011.

PROGRAM ELECTIVES:

ME6144: ALTERNATIVE FUELS [3 0 0 3]

Introduction: Estimation of conventional fuels, Advantages, and disadvantages of conventional fuels. Need for Alternative fuel, Availability and Comparative properties of Alternative fuels, classification of alternative fuels. Biofuels: Vegetable oil, Biodiesel and ethanol. Engine design modifications required & effects of design parameters on engine behaviour. Alcohols: Methods of using alcohols in CI and SI engines. Legal aspects of blending alternative fuels into conventional liquid fuels. Gaseous Fuels: Production of biogas, Factors affecting biogas formation and Usage of Biogas in SI engine & CI engine. Producer gas and their characteristics. Properties of LPG & CNG as engine fuels, Fuel metering systems, Combustion characteristics, Effect on performance, storage, Emission, Cost and safety. Other alternative fuels: Di-Methyl Ether (DME), Pyrolysis gas/oil, Synthetic gas/oil from plastic, rubber, coal, wood etc., Eco Friendly Plastic fuels (EPF).

References:

1. S.S. Thipse, *Alternative Fuels*, Jaico Publishing House, 2010.
2. Gerhard Knothe Jürgen Krahl Jon Gerpen, *The Biodiesel Handbook*, (2e) Academic Press and AOCS Press, 2010.
3. Richard L Bechtold, *Alternative Fuels Guidebook R-180*, Society of Automotive Engineers Published by SAE International, 1997.
4. G. D. Rai, *Non-Conventional Energy Sources*, Khanna Publications, 2011.

ME6145: CARBON AUDIT AND MANAGEMENT [3 0 0 3]

Greenhouse gas emissions from the energy sector and their time trend, Climate change and Other potential impacts of enhanced greenhouse effect caused by anthropogenic emissions primarily from extraction, conversion, transport, storage, and utilization of energy carriers. Carbon footprint, Carbon audit, Carbon management tools and accounting techniques. Life cycle assessment, Policies, Regulations, Protocols and Standards, Carbon credits and Carbon economics the concept of carbon sequestration. Clean development mechanism (CDM) and Its operationalization, Modalities and Procedures for CDM Project. Renewable energy certifications, Renewable purchase obligations, Automobile Emissions, Indian scenario, Impact of automobile pollutants and its abatement.

References:

1. S.M. Subramanian, *The Carbon Footprint Handbook*, CRC Pres, 2015.
2. *Carbon Handbook*, United Nations Development Programme, UNDP, 2014.
3. R Emmanuel and B. Keith, *Carbon Management in the Built Environment*, Routledge 2012.

ME6146: SOLAR ENERGY APPLICATIONS [3 0 0 3]

Solar Radiation: Extra-terrestrial and terrestrial, Radiation measuring instrument, Radiation measurement and Predictions. Solar thermal conversion: Basics, Flat plate collectors-liquid and air type. Classifications of solar thermal collectors. Theory of flat plate collectors, Selective coating, Advanced collectors. Concentrators: Optical design of concentrators, Solar water heater, Solar dryers, Solar stills, Solar ponds, Solar cooling and Refrigeration. Solar thermal power generation and Sterling engine. Solar photovoltaic: Principle of photovoltaic conversion of solar energy. Integration of thermal energy systems with various end use applications. Application of solar thermal technologies: Power generation, Industrial process heating, Water distillation, Refrigeration, Building heating and Cooling, Cooking, Drying Solar cells, Home lighting systems, Solar lanterns, Solar PV pumps, Solar energy storage options. Economic analyses of solar thermal energy systems, Life cycle assessment of solar thermal energy systems.

References:

1. Peter Heller, *The Performance of Concentrated Solar Power (CSP) Systems: Modelling, Measurement and Assessment*, Woodhead Publishing, 2017.

2. H.P. Garg and J. Prakash, *Solar Energy: Fundamentals and Applications*, McGraw Hill Education, 2017.
3. J.A. Duffie and W.A. Beckman, *Solar Engineering of Thermal Processes*, (4e), John Wiley and Sons, 2013.
4. S.A. Kalogirou, *Solar Energy Engineering: Processes and Systems*, (2e), Academic Press, 2013.
5. S. Sukhatme and J Nayak, *Solar Energy: Principles of Thermal Collection and Storage*, (3e), McGraw Hill Education, 2008.

ME6147: ENERGY CONVERSION & STORAGE [3 0 0 3]

Introduction and basic definitions, Types and forms of energy, Energy balances, Energy production via cyclic processes, Energy conversion emphasizing on thermal efficiency of the conversion processes, Energy storage techniques including thermal energy storage by sensible and latent heats, Energy Conservation, Energy coupling.

References:

1. Yasar Demirel, *Energy, Production, Conversion, Storage, Conservation and Coupling*, Springer, 2012.
2. D. Yogi Goswami and Frank Kreith, *Energy Conversion*, (2e), CRC press, 2017.

ME6247: ELECTRICAL ENERGY TECHNOLOGY & MANAGEMENT [3 0 0 3]

Transformers: Parallel operation, Auto transformers DC machines, Generator characteristics, Motor characteristics applications. Synchronous machines, Permanent magnet alternators, Induction machines. Power factor correction: Concept of power factor and reactive power, Causes and effects of low power factor, Advantages of improved power factor, Energy saving by power factor. Transmission line: Power flow study, power factor improvement, faults on power systems, Symmetrical components, Introduction to HVDC systems. Controlled rectifiers, Choppers, Inverters, Voltage regulators and Cyclo converters. Speed control of dc motors, converter, fed and chopper fed control. Speed control of AC motors, Inverter fed and AC voltage controller, fed schemes. Wind-driven induction generators, Grid connected photo-voltaic systems, Steady state performance, Integration issues, Principles of energy auditing.

References:

1. John F. Walker and N. Jenkins, *Wind Energy Technology*, John Wiley and Sons, 1997.
2. Syed A Nasar, *Electric Energy Conversion and Transmission*, Macmillan Publishing Company, New York, 1985.
3. K. V. Sharma and P. Venkataseshaiah, *Energy Management and Conservation*, I K International Publishing House Pvt. Ltd, 2011.
4. A. Garg, A.K. Bhoi, P. Sanjeevikumar, and K.K. Kamani, *Advances in Power Systems and Energy Management*. Springer Singapore, 2018.

ME6248: FUNDAMENTALS OF SOLAR PHOTOVOLTAICS [3 0 0 3]

Quantum mechanics, Crystals structures, Atomic bonding, Types of semiconductors, Energy band diagram, p-type and n-type semiconductors, Doping and Carrier concentration, Diffusion and Drift of carriers, Continuity equation, P-N junction and Its properties, Dark I-V equation of P-N junction, Junction under illumination, Solar cell and Solar PV modules, Issues with solar PV modules, Bypass diode and Blocking diode, Applications of solar PV systems, Electronic circuits in PV, Design of solar PV systems, Battery sizing, PV panel sizing, Inverter sizing, Solar lanterns, Water pumping application, Home lighting application, Cathodic protection, Remote lighting. Applications of Photovoltaic for power generation from few watts to megawatts.

References:

1. Roger A. Messenger and Amir Abtahi, *Photovoltaic Systems Engineering*, CRC Press, 2020.

2. Martin A. Green, *Solar Cells: Operating Principles, Technology and System Applications*, Longman Higher Education, 1982.
3. J. Nelson, *The Physics of Solar Cells*, Imperial College Press, 2006.
4. R. Brendel, *Thin-Film Crystalline Silicon Solar Cells: Physics and Technology*, Wiley-VCH, Weinheim, 2003.
5. Mary D Archer and Martin A Green, *Clean Electricity from Photovoltaics*, Imperial College Press, 2014.

ME6249: WASTE TO ENERGY [3 0 0 3]

Impact of waste on environment and classification of pollution. Types and sources of solid and hazardous wastes, Need for solid and hazardous waste management, Recycling and reuse, handling and Segregation of wastes. Energy from waste: Production, characterisation, and classification of waste as fuel– Biomass, Industrial waste, Municipal solid waste. Comparison of properties with conventional fuels. Power generation using waste to energy technologies. Waste to energy options: Type of thermo chemical conversion route of biomass, Direct combustion, Liquefaction, Gasification, Pyrolysis. Biochemical Conversion process, Anaerobic digestion, Fermentation, Composting. Briquetting technology: Production of solid recovered fuel (SRF) from waste and briquetted fuel. Comparison of properties of fuels derived from waste to energy technology with conventional fuels.

References:

1. Kanti L. Shah, *Basics of Solid & Hazardous Waste Management Technology*, Pearson, 1999.
2. Colin Parker, and T. Roberts, *Energy from Waste: Evaluation of Conversion Technologies*, Spon Press, 1985
3. D. O. Hall and R. P. Overend*, Biomass - Regenerable Energy*, John Willy and Sons Ltd. New York, 1987.
4. J. Pichtel, *Waste Management Practices: Municipal, Hazardous, and Industrial*, (2e), CRC Press , 2014
5. Marc J. Rogoff, and Francois Screve, *Waste-to-Energy: Technologies and Project Implementation*, (3e), Academic Press, 2019.

ME6250: ENERGY, ENVIRONMENT AND CLIMATE CHANGE [3 0 0 3]

Role of energy in economic development and social transformation. Energy and GDP, GNP and its dynamics, Impact of energy on economy, Energy sources and overall energy demand and availability. Future energy options: Sustainable development, Energy crisis, Transition from carbon rich and Nuclear to carbon free technologies. Environmental impacts of energy technologies: Limitations of traditional energy technologies, Criteria for the selection of new energy sources, Environmental degradation due to energy production and utilization, Fallout from nuclear explosions, Fuel processing and Radioactive waste. Global climate change: Causes and consequences of global warming, Ozone hole and consequence of ozone depletion, Montreal protocol, Kyoto protocol and Recent conventions. Climatic considerations in industrial locations, City planning, Landscape architecture and Abatement/mitigation of pollution, Strategies for conservation of environmental changes induced by CO_2 rise.

References:

1. C.E. Brown, *World Energy Resources*, Springer-Verlag Berlin Heidelberg, 2002.
2. G.N. Tiwari and M. K. Ghosal, *Renewable Energy Resources: Basic Principles and Applications*, Alpha Science International, Limited, 2004.
3. M. Dayal, *Renewable Energy Environment and Development*, Konark Publishers Pvt. Ltd, 1991.

ME6251: BIOMASS GASIFICATION & PYROLYSIS [3 0 0 3]

Historical background to solid waste conversion and motivation, Biomass characteristics, biomass handling, Pyrolysis and torrefaction, Tar production and destruction. Gasification theory and Modeling of gasifiers, Design of biomass gasifiers, Hydrothermal gasification of biomass. Production of synthetic fuels and chemicals from biomass. Current development and new frontiers and challenges in gasification and pyrolysis technologies.

References:

1. Prabir Basu, *Biomass Gasification, Pyrolysis and Torrefaction*, Academic Press, Elsevier, 2013.
2. Petr A. Nikrityuk and Bernd Meyer, *Gasification Processes-Modeling and Simulation*, Wiley-VCH Verlag GmbH & Co, 2014.
3. A.A. Vertes, N. Qureshi, H.P. Blaschek, H. Yukawa*, Biomass to Biofuels: Strategies for Global Industries*, Wiley, 2010.
4. S. Yang, H.A. El-Enshasy and N. Thongchul, *Bioprocessing Technologies in Biorefinery for Sustainable Production of Fuels, Chemicals and Polymers*, Wiley, 2013.
5. Shang-Tian Yang, *Bioprocessing for Value Added Products from Renewable Resources*, Elsevier, 2006.

ME6252: BIOMASS CONVERSION AND BIOREFINERY [3 0 0 3]

Introduction to biorefinery concept, Biomass characterization and pre-treatment, Physical & Thermochemical conversion processes, Review of biochemical conversion technologies, Biodiesel, Bioethanol and Biobutanol, Organic commodity chemicals from biomass, Integrated biorefinery concept.

References:

1. Donald L. Klass, *Biomass for Renewable Energy, Fuels, and Chemicals*, Academic Press, Elsevier, 2006.
2. Prabir Basu, *Biomass Gasification, Pyrolysis and Torrefaction*, Academic Press, Elsevier, 2013.
3. A.A. Vertes, N. Qureshi, H.P. Blaschek and H. Yukawa, *Biomass to Biofuels: Strategies for Global Industries*, Wiley, 2010.
4. S. Yang, H.A. El-Enshasy and N. Thongchul. *Bioprocessing Technologies in Biorefinery for Sustainable Production of Fuels, Chemicals and Polymers*, Wiley, 2013.
5. Shang-Tian Yang, *Bioprocessing for Value Added Products from Renewable Resources*, Elsevier, 2007.

ME6253: WIND AND HYDRO ENERGY SYSTEMS [3 0 0 3]

Wind machine classification, General theories of wind machines, Basic laws and concepts of aerodynamics, Description, and performance of the horizontal–axis wind machines and vertical–axis wind machines. Generation of electricity by wind machines, case studies. Wind energy conversion system (WECS) siting, Rotor selection, Annual energy output (AEO). Synchronous and asynchronous generators and loads, integration of wind energy converters to electrical networks, inverters. Overview of micro mini and small hydro, Site selection and civil works, Penstocks and Turbines, Speed and Voltage regulation, Investment issues, Load management and Tariff collection, Distribution and Marketing issues, Case studies, Wind and Hydro based stand-alone/hybrid power systems, Control of hybrid power systems, Wind diesel hybrid systems.

References:

1. J.F. Manwell, J.G. McGowan and A.L. Rogers, *Wind Energy Explained-Theory, Design and Application,* John Wiley & Sons Ltd., 2002.
2. M. O. L. Hansen, *Aerodynamics of Wind turbines*, Earthscan, 2008.
3. M. Laguna, *Guide on How to Develop a Small Hydropower Plant*, ESHA,2004.
4. L.L. Freris, *Wind Energy Conversion Systems*, Prentice Hall 1990.
5. D.A. Spera, *Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering,* ASME Press, NY 1994.

ME6132: ENERGY LAB-1 [0 0 4 2]

Preparation of biodiesel and determination of its physical properties. Elemental characterization of a fuel using CHNS(O) analyser. Study of performance characteristics of a diesel engine fuelled with different diesel-biodiesel blend. Study of performance characteristics of a spark ignition engine fuelled with alcohol-gasoline blend. Analysis of engine exhaust emission measurement using AVL DIGAS 444 analyser and AVL 437 Smoke meter. Solar radiation measurement.

References:

1. Gerhard Knothe Jürgen Krahl Jon Gerpen, *The Biodiesel Handbook*, (2e) Academic Press and AOCS Press, 2010.
2. S.S. Thipse, Alternative Fuels, Jaico Publishing House, 2010.

ME6232 ENERGY LAB-II [0 0 4 2]

Solar Radiation Data Monitoring and Analysis: Sunshine hour duration, Direct solar radiation, Global solar radiation, Diffuse solar radiation, Net radiation [W/m2], Outgoing radiation [W/m2], Infra-red radiation, Diffuse radiation from global and direct radiation at a given zenith angle. Solar Photovoltaic: Current-voltage characteristics of solar cell, Efficiency variation of solar cell, Performance variation of solar photocell at different light intensities, Determination of power produced by a solar photo voltaic system. Performance evaluation of a solar photo voltaic lighting system and its components: inverter, charge controller and battery, Performance evaluation of a solar photovoltaic water pump. Performance testing of solar cooker with and without energy storage system. Experiment on wind turbine generator. Determination of proximate analysis (Moisture content, Ash, Volatile matter & fixed carbon) for a Given Biomass Sample. Determination of Total solids, volatile Solids and calorific value for a given organic Biomass Sample. Determination of elemental analysis (chemical method) for a Given Biomass Sample.

References:

1. David C. Dayton and Thomas D. Foust, *Analytical Methods for Biomass Characterization and Conversion*, Elsevier, 2019.
2. S. P. Sukatme and J. Nayak, *Solar Energy Principles of Thermal Collection and Storage*, (3e), Tata Mc Graw Hill, 2008.

ME6233 ENERGY SIMULATION LAB [0 0 4 2]

Using PVSyst Software: Design and simulate grid-connected solar PV power plant for two sites with different latitudes under fixed tilt, seasonal tilt, and tracking, analyse average monthly performance ratio and energy production, analyse impact of thermal losses for silicon and thin film technologies, Analyse share losses for both the locations. Design and simulate Rooftop PV system for off grid application for a household. Power system simulation for engineering (PSS/E): Create and simulate an entire system in PSS/E, Determining the voltages, currents, and real and reactive power flows in a system under a given load conditions, Perform stability analysis in PSS/E. Using ANSYS FLUENT/COMSOL: Thermal energy storage related simulations. Using Design builder: To model a building. Diesel RK: Simulation of IC engines for alternate fuels.

References:

1. https://diesel-rk.bmstu.ru/
2. https://www.pvsyst.com/software-evaluation/

OPEN ELECTIVE:

ME6280: LEAN AND AGILE MANUFACTURING [3 0 0 3]

Framework of Toyota production system, Introduction to value stream mapping, Characteristics of lean value stream. Introduction to Kanban, Production smoothing, Shortening production lead time, Multifunction workers, Shortening setup time concepts and Techniques. Organization structure for promoting setup time reduction, Standardization of operations, Yo-i-Don system, One shot setup, Determining the standard quantity of work in progress, Preparing the standard operation sheet. The agile production paradigm, History of agile manufacturing, Agile manufacturing vs mass manufacturing. Agile practices, Agile practice for product development, Manufacturing agile practices, understanding the value of investing in people, Concept models of agile manufacturing, Infusing managerial principles for enabling agility.

References:

1. Y. Monden, *Toyota Production System: An Integrated Approach to Just-In-Time*, CRC Press, 2011.
2. J.M. Gross, K.R. McInnis, *Kanban Made Simple: Demystifying and Applying Toyota's Legendary Manufacturing Process*, AMACOM books, 2003
3. K.W. Dailey, D. Wieckhorst, B. Welch, *The Lean Manufacturing Pocket Handbook*, DW Publishing, 2003.
4. A. Gunasekaran, *Agile Manufacturing 21st Strategy Competitiveness Strategy*, Elsevier Publications, 2001.

ME6281: INDUSTRIAL SAFETY [3 0 0 3]

Industrial revolution, Milestones in the safety movement, Accidents & their effects, Cost of accidents, Theories of accident causation-Domino theory, Human factor theory, Accident/incident theory, Epidemiological theory, System theory, Industrial hazards, Ergonomic hazards, Mechanical hazards, Fall and Impact hazards, Temperature hazards, National Safety Council India (NSCI) and Industrial safety acts: Introduction to NSCI, Mission and Vision, Milestones, Management, NSCI safety award schemes, Safety audits, Risk assessment, NSCI safety rating system, Hazard and operational (HAZOP) studies, Industrial Safety Analysis and Management, Preliminary hazard analysis, Detailed hazard analysis, Failure mode and effect analysis (FMEA), Human error analysis (HEA), Environmental Safety: Safety, health and environment.

References:

1. L.G. David, *Occupational Safety and Health for Technologists Engineers and Managers,* (5e), Pearson-Prentice Hall, 2005.
2. F.R. Spellman, N.E. Whiting, *The Handbook of Safety Engineering: Principles and Applications*, The Scarecrow Press Inc., 2010
3. A.K. Gupta, *Industrial Safety and Environment*, Laxmi Publications (P) Ltd., 2006 4. C.R. Asfahi, D.W. Rieske, *Industrial Safety and Health Management,* (7e), Pearson, 2018.

ENERGY ECONOMICS AND POLICY

PROF. SHYAMASREE DASGUPTA
Department of Humanities and Social Sciences
IIT Mandi

PRE-REQUISITES : Any foundational course in Economics

INTENDED AUDIENCE : Primarily the graduate students working in the area of energy economics and energy policy domain. This course will also be useful for general audience

INDUSTRIES APPLICABLE TO : Power Sector; Energy consulting firms; Renewable Energy production units, Policy makers

COURSE OUTLINE :

The course deals with understanding energy as a scarce resource, various aspects of energy demand and supply with a focus to policies that are in place to promote renewable energy supply and finally, a much needed discussion on interaction between energy, environment and climate change. The course aims at broadening the vision of students while making any energy related decision as a technology developer, energy manager, entrepreneur, policy maker, researcher in future or simply for personal energy use in day to day activities.

ABOUT INSTRUCTOR :

Prof. Shyamasree Dasgupta is an Assistant Professor at the School of Humanities and Social Sciences in Indian Institute of Technology Mandi. She is an economist by training. Her teaching and research interest remains in the area of energy, environment, climate change and sustainable development. She obtained Ph.D and M.Phil in Economics from Jadavpur University, Kolkata, India with SYLFF Fellowship. She is a member of several active academic/research networks including International Association of Energy Economics, Indian Society for Ecological Economics, The Indian Econometric Society etc. She is a contributing author in the Industry Chapter of IPCC AR 5.

COURSE PLAN :

Week 1**:** Energy as a Scarce Resource; Classification, Measurement and Accounting of energy resources

Week 2**:** Energy Demand-Part I- Analyzing past, present and future demand

Week 3**:** Energy Demand-Part II - Demand Side Management, policies and behavioural issues

Week 4**:** Energy Supply- Part I – Economics and policies of non-renewable energy supply

Week 5**:** Energy Supply- Part II – Economics of electricity supply and renewable energy and related policies

Week 6**:** Energy Market

Week 7**:** Special topics on energy, environment and climate change - Part I

Week 8**:** Special topics on energy, environment and climate change - Part II

Energy Economics and Policy

COURSE OUTCOMES

- This course covers the economic principles that guide the energy-related behavior of both the producers and the consumers of energy and the policy regime that has emerged to govern it.
- The course has four building blocks: understanding energy as a scarce resource, various aspects of energy demand and supply with a focus on policies that are in place to promote renewable energy supply, and finally, a much-needed discussion on the interaction between energy, environment, and climate change.
- The course aims at broadening students' vision while making any energy-related decision as a technology developer, energy manager, entrepreneur, policy maker, or researcher in the future, or simply for personal energy use in day-to-day activities.

NPTEL Online Certification

(Funded by the MoE, Govt. of India)

This certificate is awarded to

YASH WADHAWAN

for successfully completing the course

Energy Economics And Policy

with a consolidated score of **47** %

Online Assignments	16.13/25	Proctored Exam	31.06/75

Total number of candidates certified in this course: **53**

Prof. Tushar Jain
Centre for Continuing Education
IIT Mandi

Aug-Oct 2022

(8 week course)

Prof. Andrew Thangaraj
NPTEL, Coordinator
IIT Madras