SRI SIVASUBRAMANIYA NADAR COLLEGE OF ENGINEERING

(An Autonomous Institution)
Kalavakkam – 603 110

ACADEMICS

AC 1 Sustainability Course Offerings

Submitted to

The Sustainability Tracking, Assessment & Rating System (STARS)

1.1 Percentage of academic departments and sustainability course offerings

- Total number of academic departments that offer sustainability courses
  UG: 576, PG 397

Number of sustainability focused courses offered: U.G: 31 P.G.: 21

Number of sustainability inclusive courses offered: U.G.: 42 P.G.: 35

% of courses that are sustainability course offerings: 13.25 %

- Number of academic departments with at least one sustainability course offering :13

Number of academic departments with sustainability course offerings: 09 (English/Chemistry/Civil/Mechanical/EEE/IT/BME/Chemical/MBA)

% of academic departments with sustainability course offerings: 69.23

- Annotated list or inventory of the institution's sustainability course offerings by department – Word list attached
- Description of the process used to identify the institution's sustainability course offerings by Department

The process for identifying sustainability course offerings involves mapping the courses that explicitly address sustainability-related topics or Sustainable Development Goals (SDGs). Each department reviews its curriculum to assess which courses incorporate sustainability themes. This is done by examining course content, objectives, and outcomes to determine alignment with SDGs and other sustainability frameworks. Courses that integrate social, environmental, or economic dimensions of sustainability are then categorized as sustainability courses."

Mapping of courses – B.E. Civil Engg.

Course	Sustainable Development Goals																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Water Supply Engineering			✓			✓						✓			✓		
Principles of Irrigation Engineering								✓				✓					
Wastewater Engineering			✓			✓								✓			
Energy Science and Engineering							✓	✓	✓			✓			✓		✓
Air Pollution			✓								✓		✓				
Civil Engineering - Societal and Global Impact												✓	✓		✓	✓	✓
Sustainability in Civil Engineering								✓	✓		✓	✓	✓		✓		
Municipal Solid Waste Management			✓								✓				✓		
Environmental and Social Impact Assessment								✓	✓				✓		✓	✓	
Geo-Environmental Engineering			✓												✓		
Industrial Waste Management			✓						✓								
Water Resources Engineering			✓			✓			✓								
Alternative Building Materials and Technologies							✓	✓	✓			✓					
Green Building Design							✓	✓	✓		✓	✓					
Sustainable Infrastructure							✓	✓	✓		✓	✓					
Environmental Impact Assessment								✓	✓				✓		✓	✓	
Integrated Water Resource Management			✓			✓						✓			✓		
Air pollution and Control Engineering			✓								✓		✓				

COURSE CODE	COURSE TITLE	L	T	P	C
UCE2503	WATER SUPPLY ENGINEERING	3	0	0	3

COURSE OBJECTIVES:

- To equip the students with the principles and design of water treatment and distribution

UNIT I SOURCES AND QUALITY OF WATER 9

Public water supply system – Planning, Objectives, Design period, Population forecasting. Water demand – Sources of water and their characteristics – Analytical techniques, Surface and Groundwater – Impounding

Reservoir – Development and selection of source – Source Water quality – Characterization – Significance – Drinking Water quality standards - Codal provisions.

UNIT II COLLECTION AND CONVEYANCE OF WATER 9

Water supply –Types and design of intake structures – Functions; Pipes and conduits for water – Pipe materials – Hydraulics of flow in pipes – Transmission main design – Laying, jointing and testing of pipes – appurtenances – Types and capacity of pumps – Selection of pumps and pipe materials.

UNIT III CONVENTIONAL WATER TREATMENT 9

Objectives – Unit operations and processes – Principles, functions, and design of water treatment plant units, aerators, flash mixers, Coagulation and flocculation –Design of Clarifloccuator-Plate and tube settlers - Pulsator clarifier - sand filters - Disinfection - Residue Management – Operation and Maintenance aspects.

UNIT IV ADVANCED WATER TREATMENT 9

Water softening – Iron and Manganese removal - Defluoridation - Adsorption - Desalination- R.O. Plant – demineralization process –Ion exchange– Membrane Systems – RO Reject Management - Operation & Maintenance aspects – Recent advances.

UNIT V WATER DISTRIBUTION AND SUPPLY 9

Requirements of water distribution – Components – Selection of pipe material – Service reservoirs Functions – Network design – Analysis of distribution networks – Appurtenances – Leak detection. Principles of design of water supply in buildings – House service connection – Fixtures and fittings, systems of plumbing and types of plumbing- Latest NBC provisions.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1: Demonstrate understanding on the structure of drinking water supply system, including temporal and spatial water sources, quantity and quality of water and understanding of water quality criteria and standards, and their relation to public health.

CO2: Apply the knowledge of water supply conveyance system to design intake structures, transmission mains and pumping systems.

CO3: Plan and design of unit processes and unit operations for primary water treatment

CO4: Apply the principles of advanced water treatments to design and evaluate water supply project alternatives.

CO5: Analyse water distribution networks and plan the various distribution layouts and plumbing systems

TEXTBOOKS

1. Garg, S. K., "Environmental Engineering", Vol.IKhanna Publishers, New Delhi, 2018.
2. Modi, P.N., "Water Supply Engineering", Vol.I Standard Book House, 15th Edition, New Delhi, 2018.
3. Punmia, B.C., Ashok Jain and Arun Jain, "Water Supply Engineering", Laxmi Publications, (P) Ltd., New Delhi, 2014.

REFERENCES

1. Manual on Water Supply and Treatment, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2009.
2. Syed, R., Qasim and Edward M. Motley Guang Zhu, "Water Works Engineering Planning", Design and Operation, Prentice Hall of India Learning Private Limited, New Delhi, 2009.
3. Birdie, G.S., and Birdie, J.S.,"Water Supply and Sanitary Engineering", Dhanpat Rai Publishing Company, 2010

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	-	3	3	-	-	2	-	-	-	-

CO2	2	2	3	2	-	2	3	-	-	-	-	3	3	-
CO3	2	-	3	3	-	3	2	-	-	3	-	-	2	3
CO4	2	2	3	3	-	3	2	-	-	3	-	3	1	3
CO5	2	3	2	3	-	2	2	-	-	-	-	2	2	2

COURSE CODE	COURSE TITLE	L	T	P	C
UCE2602	PRINCIPLES OF IRRIGATION ENGINEERING	3	0	0	3

COURSE OBJECTIVES:

- The student is exposed to different phases in irrigation practices and Planning and management of irrigation. Further they will be imparted required knowledge on Irrigation storage and distribution canal system and Irrigation management.

UNIT I CROP WATER REQUIREMENT 9

Need and classification of irrigation- historical development and merits and demerits of irrigation-types of crops-crop season-duty, delta and base period- consumptive use of crops- estimation of Evapotranspiration using experimental and theoretical methods

UNIT II IRRIGATION METHODS 9

Tank irrigation – Well irrigation – Irrigation methods: Surface and Sub-Surface and Micro Irrigation – design of drip and sprinkler irrigation – ridge and furrow irrigation-Irrigation scheduling – Water distribution system- Irrigation efficiencies.

UNIT III DIVERSION AND IMPOUNDING STRUCTURES 9

Types of Impounding structures - Gravity dam – Forces on a dam -Design of Gravity dams; Earth dams, Arch dams- Diversion Head works - Weirs and Barrages-

UNIT IV CANAL IRRIGATION 9

Canal regulations – direct sluice - Canal drop – Cross drainage works-Canal outlets – Design of prismatic canal-canal alignments-Canal lining - Kennedy's and Lacey's Regime Theory-Design of unlined canal

UNIT V WATER MANAGEMENT IN IRRIGATION 9

Modernization techniques- Rehabilitation – Optimization of water use-Minimizing water losses- On form development works-Participatory irrigation management- Water resources associations- Changing paradigms in water management-Performance Evaluation-Economic aspects of irrigation

TOTAL :45 PERIODS

COURSE OUTCOMES:

On successful completion of this course, the student will be able to

CO1: Estimate the water requirements for crop water.
CO2: Demonstrate understanding on the soil plant water characteristics
CO3: Design the various types of hydraulic structure includes dams, spillways and dissipaters
CO4: Design the components of irrigation canal includes canal drops and cross drainage works
CO5: Apply the concepts of Irrigation water management, water user association for participatory irrigation management

TEXTBOOKS

1. Dilip Kumar Majumdar, "Irrigation Water Management", Prentice-Hall of India, New Delhi, 2008.
2. Punmia B.C., and Pande, B.B, "Irrigation and waterpower Engineering", Laxmi Publications, 16th Edition, New Delhi, 2009.
3. Garg, S.K., "Irrigation Engineering and Hydraulic structures", Khanna Publishers, 23rd Revised Edition, New Delhi, 2009.

REFERENCES

1. Duggal, K.N., Soni, J.P., "Elements of Water Resources Engineering", New Age International Publishers, 2005.
2. Linsley, R.K., Franzini, J.B., "Water Resources Engineering", McGraw-Hill Inc, 2000.
3. Chaturvedi, M.C., "Water Resources Systems Planning and Management", Tata McGraw- Hill Inc., New Delhi, 1997.
4. Sharma, R.K., "Irrigation Engineering", S.Chand & Co. 2007.
5. Michael A.M., "Irrigation Theory and Practice", 2nd Edition, Vikas Publishing House Pvt. Ltd., Noida, Up, 2008
6. Asawa, G.L., "Irrigation Engineering", New Age International Publishers, New Delhi, 2000.
7. Basak, N.N., "Irrigation Engineering", Tata McGraw Hill Publishing Co. New Delhi,1999.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2							2	2		-	3	3
CO2	2	3								2	-		2	
CO3	3	2	3	3		3	2	2	3	3		-	3	2
CO4	2	3	3			2	2	2	2	2		-	2	3
CO5	3	2		3	1	2					-	-		3

COURSE CODE	COURSE TITLE	L	T	P	C
UCE2603	WASTEWATER ENGINEERING	3	0	0	3

COURSE OBJECTIVES:

- The objectives of this course is to help students develop the ability to apply basic understanding of physical, chemical, and biological phenomena for successful design, operation and maintenance of sewage treatment plants.

UNIT I PLANNING AND DESIGN OF SEWERAGE SYSTEM 9

Characteristics and composition of sewage - population equivalent -Sanitary sewage flow estimation - Sewer materials – Hydraulics of flow in sanitary sewers – Sewer design – Storm Drainage- Storm runoff estimation – sewer appurtenances – corrosion in sewers – prevention and control – sewage pumping-drainage in buildings-plumbing systems for drainage – Wastewater standards and legislations - Rain Water Harvesting.

UNIT II PRIMARY TREATMENT OF SEWAGE 8

Objectives – Unit Operations and Processes – Selection of treatment processes – Onsite sanitation - Septic tank - Grey water harvesting – Primary treatment – Principles, functions and design of sewage treatment units - screens - grit chamber-primary sedimentation tanks – Construction, Operation and Maintenance aspects.

UNIT III SECONDARY TREATMENT OF SEWAGE 10

Objectives – Selection of Treatment Methods – Principles, Functions, - Activated Sludge Process and Extended aeration systems –Rotating biological Contactors-Trickling Filters Waste Stabilization Ponds – Operation and Maintenance

UNIT IV ADVANCES IN SEWAGE TREATMENT 8

Sequencing Batch Reactor – Moving bed biofilm Reactor-Membrane Bioreactor - UASB – Biogas recovery- Reclamation and Reuse of sewage – Constructed Wetland –Nutrient removal systems.

UNIT V SEWAGE DISPOSAL AND SLUDGE MANAGEMENT 10

Dilution – Self-purification of surface water bodies Oxygen sag curve – deoxygenation and reaeration - Land disposal – Sewage farming – sodium hazards - Soil dispersion system. Objectives - Sludge characterization – Sludge Thickening – Dewatering – Drying - ultimate
residue disposal – Septage Management.

TOTAL: 45 HOURS

COURSE OUTCOMES:

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

CO1: Demonstrate understanding on the characteristics and composition of sewage, analyse sewage generation and design sewer system including sewage pumping stations.

CO2: Plan and design of unit processes and unit operations for primary sewage treatment.

CO3: Plan and design of unit processes and unit operations for secondary sewage treatment.

CO4: Apply the principles of advanced sewage treatments to design and evaluate sewage treatment and reclamation project alternatives.

CO5: Outline the concepts of self-purification of streams, sludge and septage disposal methods.

CO6 Analyze effluent data and perform a design of an effluent treatment plant.

TEXTBOOKS

1. Garg, S.K.,"Environmental Engineering" Vol. II, Khanna Publishers, New Delhi, 2015.
2. Modi, P.N., "Sewage Treatment Disposal & Wastewater Engineering", Standard Book House, 17th Edition, New Delhi, 2020.
3. Punmia, B.C. Jain, A.K. and Jain, A.K., "Environmental Engineering", Vol.II, Laxmi Publications, 2010

REFERENCES

1. Manual on Sewerage and Sewage Treatment Systems Part A, B and C, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013.
2. Metcalf, Eddy, "Wastewater Engineering–Treatment and Reuse", Tata Mc.Graw-Hill Company, New Delhi, 2010.
3. Syed R. Qasim,"Waste water Treatment Plants", CRC Press, Washington D.C.,2010.
4. Gray, N.F., "Water Technology", Elsevier India Pvt. Ltd., New Delhi, 2006.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2		2	3		-	2							
CO2	3	2	3	2	2			3	-	-		2	3	2
CO3	3	2	3	2	2			3	-	-		2	3	3
CO4	3	3	3	3		-	3	3	-	-		3	3	3
CO5	2	2	2	2	2	-	3		-	-		2	2	2
CO6	2	2	3	3		1	2		3	3		2	2	2

COURSE CODE	COURSE TITLE	L	T	P	C
UCE2703	ENERGY SCIENCE AND ENGINEERING	3	0	0	3

COURSE OBJECTIVES

- To provide an introduction to energy systems and renewable energy resources, with a scientific examination of the energy field and an emphasis on alternative energy sources and its application from Civil Engineering perspective.
- The knowledge acquired lays a good foundation for design of various civil engineering systems/projects dealing with these energy generation paradigms in an efficient manner.

UNIT 1 INTRODUCTION TO ENERGY SCIENCE 9

Scientific principles and historical interpretation to place energy use in the context of pressing societal, environmental and climate issues; Introduction to energy systems and resources; Introduction to Energy, sustainability & the environment

UNIT II ENERGY SOURCES 9

Overview of energy systems, sources, transformations, efficiency, and storage. Fossil fuels - past, present & future, Remedies & alternatives for fossil fuels - biomass, wind, solar, nuclear, wave, tidal and hydrogen; Sustainability and environmental trade-offs of different energy system

UNIT III ENERGY & ENVIRONMENT 9

Energy efficiency and conservation; Introduction to clean energy technologies and its importance in sustainable development; Carbon footprint, energy consumption and sustainability; Introduction to the economics of energy; linkages between economic and environmental outcomes.

UNIT IV CIVIL ENGINEERING PROJECTS CONNECTED WITH THE ENERGY SOURCES 9

Coal mining technologies, Oil exploration offshore platforms, Underground and under-sea oil pipelines, solar chimney project, wave energy caissons, coastal installations for tidal power, windmill towers; hydro power stations above-ground and underground along with associated dams, tunnels, penstocks and Nuclear reactor containment buildings.

UNIT V ENERGY CONSERVATION IN BUILDINGS 9

Green building concepts; LEED ratings; Embodied energy analysis and use as a tool for measuring sustainability. Energy Audit of Facilities and optimization of energy consumption. Concept of Green composites and Green Architecture; Low energy approaches to water Management; Management of sullage water and sewage.

TOTAL:45 PERIODS

COURSE OUTCOMES:

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

CO1: Explain the main sources of energy and their primary applications nationally and internationally

CO2: Demonstrate understanding on the different energy sources including fossil fuels and the principles behind them.

CO3: Describe the challenges and problems associated with the use of various energy sources and the impact on the environment.

CO4: Demonstrate understanding on the Engineering involved in Civil Engineering projects utilizing these energy sources.

CO5: Apply green building concepts to minimize energy consumption for sustainable building construction.

TEXT BOOKS:

1. Boyle, Godfrey, Bob Everett, and Janet Ramage (Eds.) (2012), "Energy Systems and Sustainability: Power for a Sustainable Future". Oxford University Press.

REFERENCE BOOKS:

1. Boyle, Godfrey (2012), "Renewable Energy" (3rd edition). Oxford University Press.
2. Schaeffer, John (2014), "Real Goods Solar Living Sourcebook: The Complete Guide to Renewable Energy Technologies and Sustainable Living", Gaiam.
3. Ristinen, Robert A. Kraushaar, Jack J. Kraushaar, A., Jack P. Ristinen, Robert A. (2015) "Energy and the Environment", 3rd Edition, John Wiley.
4. Osman Attman (2010), "Green Architecture Advanced Technologies and Materials". McGraw Hill.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	1	-	1	3	-	-	-	-	2		2
CO2	2	1	1	1	-	1	3	-	-	-	-		3	
CO3	2	1	3	1	-	1	2	-	-	-	-		2	2
CO4	2	1	3	1	-	1	2	-	-	-	-	2	2	3
CO5	2	1	3	1	-	1	3	-	-	-	-	3	2	3

COURSE CODE	COURSE TITLE	L	T	P	C
UCE2523	**AIR POLLUTION**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

- To impart knowledge on the principle and design of control of Indoor/ particulate/ gaseous air pollutant and its emerging trends.

UNIT I AIR QULALITY 9

Structure and composition of Atmosphere – Definition, Scope and Scales of Air Pollution – Sources and classification of air pollutants and their effect on human health, vegetation, animals, property, aesthetic value and visibility- Ambient Air Quality and Emission standards – Ambient and stack sampling and Analysis of Particulate and Gaseous Pollutants.

UNIT II ATMOSPHERIC DISPERSION OF AIR POLLUTANT 8

Effects of meteorology on Air Pollution - Fundamentals, Atmospheric stability, Inversion, Wind profiles and stack plume patterns- Atmospheric Diffusion Theories – Dispersion models, Plume rise

UNIT III AIR POLLUTION CONTROL 11

Concepts of control – Principles and design of control measures – Particulates control by gravitational, centrifugal, filtration, scrubbing, electrostatic precipitation – Selection criteria for equipment - gaseous pollutant control by adsorption, absorption, condensation, combustion –Pollution control for specific major industries.

UNIT IV AIR QUALITY MANAGEMENT 8

Air quality standards – Air quality monitoring – Preventive measures - Air pollution control efforts – Zoning – Town planning regulation of new industries – Legislation and enforcement –Environmental Impact Assessment and Air quality

UNIT V INDOOR AIR QUALITY MANAGEMENT 9

Source types and control of indoor air pollutants, sick building syndrome types –Sources and Effects of Noise Pollution – Measurement – Standards–Control and Preventive measures

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On successful completion of this course, the students will be able to demonstrate understanding on:

CO1: Apply the knowledge of atmospheric chemistry and characteristics of air pollutant to describe the effects of air pollution

CO2: Apply the knowledge of mathematics, science, and engineering fundamentals to understand the concept of meteorology, air pollution dispersion and Gaussian plume dispersion model

CO3: Plan and design of unit processes and unit operations for the gaseous and particulate pollutant control equipment

CO4: Explain the various legislation and methods of Air Quality Management

CO5: Demonstrate understanding on the source of indoor air pollution, effects and control methods as well as to identify the source of noise, and select suitable method for measuring and control of noise pollution

TEXTBOOKS

1. Lawrence K. Wang, Norman C. Pareira, Yung Tse Hung, "Air Pollution Control Engineering", Tokyo, 2004.
2. Noel de Nevers, "Air Pollution Control Engineering", Mc Graw Hill, 3rd Ed., New York, 2016.
3. Anjaneyulu, Y., "Air Pollution and Control T"echnologies, Allied Publishers (P) Ltd., 2nd Ed., India 2020.

REFERENCES

1. Cooper, C.D., Alley, F.C., "Air Pollution Control A Design Approach", Waveland Press, Inc, Illinois, USA, 2010
2. David, H.F., Liu, Bela G. Liptak, A "Air Pollution" , Lweis Publishers, 2000.
3. Arthur C.Stern, "Air Pollution" (Vol.I – Vol.VIII), Academic Press, 2006.
4. Wayne T.Davis, "Air Pollution Engineering Manual", John Wiley & Sons, Inc.,2000.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2			2		3	2					2	1	3
CO2	3	3		2	3							2	3	
CO3	3	2	3	2				3	3	3				3
CO4	1					2	3					3		3
CO5	2			1		3	2					3	3	2

COURSE CODE	COURSE TITLE	L	T	P	C
UCE2542	CIVIL ENGINEERING – SOCIETAL AND GLOBAL IMPACT	3	0	0	3

COURSE OBJECTIVES

- The student will be able to know and understand the impact of Civil Engineering on the society and environment.

UNIT I INTRODUCTION 8

Understanding the past to look into the future: Pre-industrial revolution days, Agricultural revolution, first and second industrial revolutions, IT revolution; Recent major Civil Engineering breakthroughs and innovations; Understanding the importance of Civil Engineering in shaping and impacting the world; The ancient and modern Marvels and Wonders in the field of Civil Engineering; Future Vision for Civil Engineering; the steady erosion in Sustainability; Evaluating future requirements for various resources

UNIT II INFRASTRUCTURE 10

Infrastructure - Habitats, Megacities, Smart Cities, futuristic visions; Transportation (Roads, Railways & Metros, Airports, Seaports, River ways, Sea canals, Tunnels (below ground, under water); Futuristic systems (ex, Hyper Loop)); Energy generation (Hydro, Solar (Photovoltaic, Solar Chimney), Wind, Wave, Tidal, Geothermal, Thermal energy); Water provisioning; Telecommunication needs (towers, above-ground and underground cabling); Awareness of various Codes & Standards governing Infrastructure development; Innovations and methodologies for ensuring Sustainability

UNIT III ENVIRONMENT 8

Environment - Traditional & futuristic methods; Solid waste management, Water purification, Wastewater treatment & Recycling, Hazardous waste treatment; Flood control (Dams, Canals, River interlinking), Multi-purpose water projects, Atmospheric pollution; Global warming phenomena and Pollution Mitigation

measures, Stationarity and non-stationarity; Environmental Metrics & Monitoring; Other Sustainability measures; Innovations and methodologies for ensuring Sustainability.

UNIT IV BUILT ENVIRONMENT 9

Built environment – Facilities management, Climate control; Energy efficient built environments and LEED ratings, Recycling, Temperature/ Sound control in built environment, Security systems; Intelligent/ Smart Buildings; Aesthetics of built environment, Role of Urban Arts Commissions; Conservation, Repairs & Rehabilitation of Structures & Heritage structures; Innovations and methodologies for ensuring Sustainability.

UNIT V IMPACT OF CIVIL PROJECTS 10

Civil Engineering Projects – Environmental Impact Analysis procedures; Waste (materials, manpower, equipment) avoidance/ Efficiency increase; Advanced construction techniques for better sustainability; Techniques for reduction of Green House Gas emissions in various aspects of Civil Engineering Projects; New Project Management paradigms & Systems (Ex. Lean Construction), contribution of Civil Engineering to GDP, Contribution to employment(projects, facilities management), Quality of products, Health & Safety aspects for stakeholders; Innovations and methodologies for ensuring Sustainability during Project development.

TOTAL:45 PERIODS

COURSE OUTCOMES:

At the end of the course the student will be able to

CO1: Outline the importance of civil engineering and the impact on the society and global level.
CO2: Compile and compare the societal impacts of Civil engineering infrastructures.
CO3: Discuss the impacts of civil engineering in the environmental field.
CO4: Critique the impacts of civil engineering in the built environment.
CO5: Compile and discuss the Global and Societal impacts of civil engineering projects.

TEXT BOOKS:

1. Rethaliya, R.P., and Rethaliya, M.P., "Civil Engineering – Societal and Global Impact", First Edition, Atul Prakashan, Ahmedabad, 2020.
2. Žiga Turk Global Challenges and the Role of Civil Engineering, Chapter 3 in: Fischinger M. (eds) Performance-Based Seismic Engineering: Vision for an Earthquake Resilient Society. Geotechnical, Geological and Earthquake Engineering, Vol. 32. Springer, Dordrecht, 2014.

REFERENCES:

1. Brito, Ciampi, Vasconcelos, Amarol, Barros, "Engineering impacting Social, Economic and Working Environment", 120th ASEE Annual Conference and Exposition, 2013.
2. NAE Grand Challenges for Engineering, "Engineering for the Developing World", The Bridge, Vol 34, No.2, Summer 2004.
3. Allen, M.., "Cleansing the city". Ohio University Press. Athens Ohio, 2008.
4. Ashley, R., Stovin, V., Moore, S., Hurley, L., Lewis, L., Saul, A., London Tideway Tunnels Programme – Thames Tunnel Project Needs Report – Potential source control and SUDS applications: Land use and retrofit options , 2010.
5. Ashley, RM., Nowell, R., Gersonius, B., Walker, L., "Surface Water Management and Urban Green Infrastructure. Review of Current Knowledge". Foundation for Water Research FR/R0014, 2011.
6. Barry, M.., "Corporate social responsibility – unworkable paradox or sustainable paradigm?" Proc ICE Engineering Sustainability 156. Sept Issue ES3 paper 13550. P 129-130,2003.
7. Blackmore, JM., Plant, R A J., "Risk and resilience to enhance sustainability with application to urban water systems". J. Water Resources Planning and Management. ASCE. Vol. 134, No. 3, May, 2008.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	1	-	3	2	1	1	2	-	3	1	-
CO2	2	2	-	2	-	3	1	1	1	2	2	2	2	3
CO3	3	2	1	2	-	3	3	1	1	2	1	3	2	3
CO4	2	1	1	3	-	3	2	1	1	2	1	2	2	3
CO5	3	2	1	1	-	3	2	1	1	2	3	2	3	2

COURSECODE	COURSE TITLE	L	T	P	C
UCE2527	SUSTAINABILITY IN CIVIL ENGINEERING	3	0	0	3

COURSE OBJECTIVES:

- To impart knowledge to the students on the basic concepts of sustainability related to civil engineering such as sustainable materials, structures, geotechnical and transportation engineering, green certification rating systems, and life cycle analysis.

UNIT I INTRODUCTION TO SUSTAINABILITY 9

Definition- Development of sustainability through United Nations- Incorporating sustainability in civil engineering- Responsibility of civil engineer in sustainable development- Economic sustainability- Life cycle cost analysis- Cost benefit analysis- rate of return- - Future trends of sustainability.

UNIT II SUSTAINABLE MATERIALS 9

Sustainable construction materials- Use of waste materials in bulk quantities- Fly ash- Bamboo- - demolition wastes- Bricks- Alternate cementitious materials- High performance concrete- Assessment of performance of sustainable materials and structural systems- Steel diagrids- Innovative and smart materials- Carbon balance.

UNIT III GEOTECHNICAL SUSTAINABILITY 9

Principles of sustainability in geotechnical practice- Ground improvement- Alternate granular fills- Retaining walls- Mechanically stabilised earth walls- Ground water retention techniques- Societal impact of ground water recharge techniques- Case studies.

UNIT IV TRANSPORTATION SUSTAINABILITY 9

Sustainable transportation- Multi modal transportation- Emission reduction analysis- Alternate modes for sustainable living- Recycled materials in pavements- RAS- RAP- Recycled plastics-. Concepts of intelligent hybrid transportation systems- Safety of transportation systems- Crash modification factors.

UNIT V SUSTAINABLE BUILDING PRACTICES 9

Social sustainability- Social Impact assessment – Energy efficiency in construction and buildings- Green certification and Rating systems- Best practices for green building certification- International and national regulations.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Assess the economic sustainability of civil engineering projects by cost benefit and life cycle analysis.

CO2: Select alternate materials and assess its properties.

CO3: Assess the various alternatives for geotechnical fills and ground water retention.

CO4: Analyse multi modal transportation systems and study the performance of alternate materials in transportation.

CO5: Perform social impact assessment and rating systems in civil engineering projects.

TEXTBOOKS:

1. Andrew Abraham, Sadie Casillas, "Fundamentals of Sustainability in Civil Engineering", CRC Press, Taylor and Francis Group, 2021.
2. Sharon B. Jaffe, Rob Fleming, Mark Karlen, Saglinda H. Roberts, "Sustainable Design Basics", John Wiley and Sons, 2020.

REFERENCES:

1. Ross Speigel, Dru Meadows, "Green building materials- A guide to product selection and specification", John Wiley and Sons, Third ed.
2. Sam Kubba. "Handbook of Green building design and construction", Elsevier, 2014.
3. Sivakumar Babu, Sireesh Saride, Munwar Basha, "Sustainability Issues in Civil Engineering", Springer Transactions in Civil and Environmental Engineering. Springer Nature, 2017.
4. Yates J K, Daniel Castro Lacouture, "Sustainability in Engineering Design and Construction", CRC Press, Taylor and Francis Group, 2018.
5. Jamal Khatib, "Sustainability of Construction Materials", Woodhead Publishing No 70, Elsevier, 2016.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3				2	3					2	3	2
CO2	3	2				2	2	1	2	2		3	3	2
CO3	3	3	3			2	3	1				2	1	3
CO4	3	2				2	2			2	2	1	2	3
CO5	3	2	1			2	3	1	1	2	2	3	2	3

COURSE CODE	COURSE TITLE	L	T	P	C
UCE2528	MUNICIPAL SOLID WASTE MANAGEMENT	3	0	0	3

COURSE OBJECTIVES:

- To make the students conversant with the types, sources, generation, storage, collection, transport, processing and disposal of municipal solid waste.

UNIT I SOURCES AND CHARACTERISTICS 8

Sources and types of municipal solid wastes-waste generation rates-factors affecting generation, characteristics-methods of sampling and characterization; Effects of improper disposal of solid wastes-Public health and environmental effects. Elements of solid waste management –Social and Financial aspects – l solid waste (M&H) rules – integrated solid waste management-Public awareness; Role of NGO‟ s- Public Private participation

UNIT II ON-SITE STORAGEAND PROCESSING 8

On-site storage methods – Effect of storage, materials used for containers – segregation of solid wastes – Public health and environmental aspects of open storage – waste segregation and storage – case studies under Indian conditions – source reduction of waste – Reduction, Reuse and Recycling of plastic waste – Construction and Demolishing waste.

UNIT III COLLECTION AND TRANSFER 8

Methods of Residential and commercial waste collection – Collection vehicles – Manpower – Collection routes – Analysis of collection systems; Transfer stations – Selection of location, operation & maintenance; options under Indian conditions – Field problems- solving.

UNIT IV OFF-SITE PROCESSING 12

Objectives of waste processing – Physical Processing techniques and Equipment; Resource recovery from solid waste composting and biomethanation; Thermal processing options – case studies under Indian conditions.

UNIT V DISPOSAL 9

Land disposal of solid waste; Sanitary landfills – site selection, design and operation of sanitary landfills – Landfill liners – Management of leachate and landfill gas- Landfill bioreactor – Dumpsite capping – Biomining.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Demonstrate understanding on the nature and characteristics of municipal solid wastes and regulatory requirements regarding municipal solid waste management

CO2: Explain the segregation of solid waste and the onsite storage methods

CO3: Analyze the various transfer methods and to know the site condition for the transfer station

CO4: Apply technical knowledge to select appropriate methods for processing and disposal of sol and hazardous wastes, considering the impact of the solutions in a sustainability context

CO5: Apply knowledge in selection of appropriate disposal methods and its handling in an efficie Manner

TEXTBOOKS

1. Cherry P M, "Solid and Hazardous Waste Management", CBS publishers and distributors Pvt Ltd, 2018.
2. Rao M.N, Razia Sultana, Sri Harsha Kota, "Solid and hazardous waste management – Science and Engineering", Butterworth-Heinemann, 2016.

REFERENCES

1. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, "Integrated Solid Waste Management, Mc-Graw Hill India, First edition, 2015.
2. CPHEEO, "Manual on Municipal Solid waste management, Vol I, II and III", Central Public Health and Environmental Engineering Organisation , Government of India, New Delhi, 2016.
3. William A. Worrell, P. Aarne Vesilind, Christian Ludwig, "Solid Waste Engineering - A Global Perspective", 3rd Edition, Cengage Learning, 2017.
4. Michael D. LaGrega, Philip L Buckingham, Jeffrey C. E vans and "Environmental Resources Management, Hazardous waste Management", Mc-Graw Hill International edition, New York, 2010.
5. John Pitchtel, "Waste Management Practices", CRC Press, Taylor and Francis Group,2014.
6. Gary C. Young, "Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons", Wiley, 2010.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1		2		3	2					2	1	3
CO2	1	3		2	3								3	1
CO3	3	2	3	3			3	2	2	2				3
CO4	3	2	3	2		3	3	2	2	2				3
CO5	3	3		2		3	3					3	3	2

COURSE CODE	COURSE TITLE	L	T	P	C
UCE2623	ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT	3	0	0	3

COURSE OBJECTIVES:

- To impart the knowledge and skills to identify, assess and mitigate the environmental and social impacts of developmental projects.

UNIT I INTRODUCTION 9

Impacts of Development on Environment – Rio Principles of Sustainable Development- Environmental Impact Assessment (EIA) – Objectives – Historical development – EIA Types – EIA in project cycle –EIA Notification and Legal Framework

UNIT II ENVIRONMENTAL ASSESSMENT 9

Screening and Scoping in EIA – Drafting of Terms of Reference, Baseline monitoring, Prediction and Assessment of Impact on land, water, air, noise, flora and fauna - Matrices – Networks – Checklist Methods - Mathematical models for Impact prediction.

UNIT III ENVIRONMENTAL MANAGEMENT PLAN 9

Plan for mitigation of adverse impact on water, air and land, water, energy, flora and fauna –Environmental Monitoring Plan – EIA Report Preparation – Public Hearing-Environmental Clearance

UNIT IV SOCIO ECONOMIC ASSESSMENT 9

Baseline monitoring of Socio-economic environment – Identification of Project Affected Personal – Rehabilitation and Resettlement Plan- Economic valuation of Environmental impacts – Cost benefit Analysis-.

UNIT V CASE STUDIES 9

EIA case studies pertaining to Infrastructure Projects – Roads and Bridges – Mass Rapid Transport Systems - Airports - Dams and Irrigation projects - Power plants

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students completing the course will have ability to

CO1: Explain the framework of Environmental Impact Assessment, historical development and Rio Principles.

CO2: Demonstrate understanding on the procedure for performing an Environmental Impact Assessment. carry out scoping and screening of developmental projects for environmental assessments

CO3: Identify appropriate methodologies for environmental impact prediction and assessment. Prepare and evaluate environmental impact assessment reports.

CO4: Explain the procedure for performing Social Impact Assessment. carry out Economic valuation and cost benefit analysis of environmental impacts.

CO5: Study and analyze EIA case studies for various infrastructure projects

TEXTBOOKS

1. Canter R.L, "Environmental impact Assessment", 2nd Edition, McGraw Hill Inc, New Delhi,1995.
2. Lohani B, Evans J W, Ludwig H, Everitt R R, Richard A. Carpenter, and Tu S.L, "Environmental Impact Assessment for Developing Countries in Asia", Volume 1 – Overview, Asian Development Bank,1997.
3. Peter Morris, Riki Therivel, "Methods of Environmental Impact Assessmen"t, Routledge Publishers,2009.

REFERENCES

1. Becker H A, Frank Vanclay, "The International handbook of social impact assessment conceptual and methodological advances", Edward Elgar Publishing, 2003.
2. Barry Sadler and Mary McCabe, "Environmental Impact Assessment Training Resource Manual", United Nations Environment Programme, 2002.
3. Judith Petts, "Handbook of Environmental Impact Assessment Vol. I and II", Blackwell Science New York, 1998.
4. Ministry of Environment and Forests EIA Notification and Sectoral Guides, Government of India, New Delhi, 2010.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3						2				2		3	
CO2	3						2		2	2	2			
CO3	2	3				3	2		3	3		3	3	3
CO4	3	3	2	2		3	3	3						2
CO5	2	3	3	2		3			2	2	2	3	1	1

COURSE CODE	COURSE TITLE	L	T	P	C
UCE2724	GEOENVIRONMENTAL ENGINEERING	3	0	0	3

COURSE OBJECTIVES:

- The student acquires knowledge on the geotechnical engineering problems associated with soil contamination, safe disposal of waste and remediate the contaminated soils by different techniques thereby protecting environment

UNIT I GENERATION OF WASTES AND CONSEQUENCES OF SOIL POLLUTION 8

Introduction to Geo environmental engineering – Environmental cycle – Sources, production and classification of waste – Causes of soil pollution – Factors governing soil pollution interaction clay minerals - Failures of foundation due to waste movement.

UNIT II SITE SELECTION AND SAFE DISPOSAL OF WASTE 10

Safe disposal of waste – Site selection for landfills – Characterization of land fill sites and waste – Risk assessment – Stability of landfills – Current practice of waste disposal – Monitoring facilities – Passive containment system – Application of geosynthetics in solid waste management – Rigid or flexible liners.

UNIT III TRANSPORT OF CONTAMINANTS 8

Contaminant transport in sub surface – Advection, Diffusion, Dispersion – Governing equations – Contaminant transformation – Sorption – Biodegradation – Ion exchange – Precipitation – Hydrological consideration in land fill design – Ground water pollution.

UNIT IV WASTE STABILIZATION 10

Stabilization - Solidification of wastes – Micro and macro encapsulation – Absorption, Adsorption, Precipitation – Detoxification – Mechanism of stabilization – Organic and inorganic stabilization – Utilization of solid waste for soil improvement – case studies.

UNIT V REMEDIATION OF CONTAMINATED SOILS 9

Insitu remediation-Solidification, bio-remediation, incineration, soil washing, phyto remediation, soil heating, vitrification, bio-venting.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Assess the contaminates in the soil
CO2: Discuss the current practice of waste disposal
CO3: Identify a suitable disposal system for contaminants waste
CO4: Select relevant waste stabilisation technique and utilisation of the waste for soil improvement
CO5: Prepare appropriate methodology for remediation based on contamination

TEXTBOOKS:

1. Hari, Sharma D, Krishna R. Reddy, "Geo-Environmental Engineering ", John Wiley and Sons, INC, USA, 2004.
2. Daniel B.E, "Geotechnical Practice for waste disposal", Chapman & Hall, London 1993.
3. Manoj Datta, "Waste Disposal in Engineered landfills", Narosa Publishing House, 2001.
4. Manoj Datta, B.P. Parida, B.K. Guha, "Industrial Solid Waste Management and Land filling Practice", Narosa Publishing House, 2001.

REFERENCES

1. Westlake K, "Landfill Waste pollution and Control", Albion Publishing Ltd., England, 1995.
2. Wentz C.A, "Hazardous Waste Management", McGraw Hill, Singapore, 1989.
3. Proceedings of the International symposium on "Environmental Geotechnology" (Vol.I and II). Environmental Publishing Company, 1986 and 1989.
4. Ott W.R, "Environmental indices, Theory and Practice", Ann Arbor, 1978.
5. Fried J J, "Ground Water Pollution", Elsevier, 1975.
6. ASTM Special Tech. Publication 874, Hydraulic Barrier in Soil and Rock, 1985.
7. Lagrega M.D, Buckinham P.L, Evans J.C , "Hazardous Waste Management", McGraw Hill Inc. Singapore, 1994

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1		2	3	3	3	3	1			1	3	3	1
CO2	2		2	2	1	2	2	2			1	2		1
CO3	3	3	3	2	2	3	3	2			1	2		3
CO4	1		1			2	3				1	2		1
CO5	1		2	3	3	3	3	1				3		2

COURSE CODE	COURSE TITLE	L	T	P	C
UCE2824	INDUSTRIAL WASTE MANAGEMENT	3	0	0	3

COURSE OBJECTIVES:

- This subject deals with the pollution from major industries and methods of controlling the same. The student is expected to know about the polluting potential of major industries in the country and the methods of controlling the same.

UNIT I INTRODUCTION 8

Types of industries and industrial pollution – Characteristics of industrial wastes – Population equivalent – Bioassay studies – effects of industrial effluents on streams, sewer, land, sewage
treatment plants and human health – Environmental legislations related to prevention and control of industrial effluents and hazardous wastes.

UNIT II CLEANER PRODUCTION 8

Waste management Approach – Waste Audit – Volume and strength reduction – Material and process modifications – Recycle, reuse and byproduct recovery – Applications.

UNIT III POLLUTION FROM MAJOR INDUSTRIES 9

Sources, Characteristics, waste treatment flow sheets for selected industries such as Textiles, Tanneries, Pharmaceuticals, Distilleries, Refineries, Dairy, Thermal power plants – Wastewater reclamation concepts.

UNIT IV TREATMENT TECHNOLOGIES 11

Equalisation – Neutralisation – Removal of suspended and dissolved organic solids - Chemical oxidation - Adsorption - Removal of dissolved inorganics – Combined treatment of industrial and municipal wastes - Residue management – Dewatering – Disposal

UNIT V SLUDGE AND HAZARDOUS WASTE MANAGEMENT 9

Residuals of Industrial Wastewater treatment – Quantification and Characteristics of Sludge –Thickening, Digestion, Conditioning, Dewatering and Disposal of Sludge – Solidification – Incineration – Secured Landfills-Hazardous waste management.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Demonstrate understanding on the source and types of industrial wastewater and their environmental impacts and choose the regulatory laws pertaining to environmental protection

CO2: Analyse and audit waste production to design process modification, recycling and reduction of waste for cleaner production

CO3: Explain the sources, characteristics, and effects of pollution from major industries.

CO4: Design facilities for the processing and reclamation of industrial wastewater

CO5: Plan and develop sludge management scheme for sludge generated from industries

TEXTBOOKS

1. Rao M.N,.Dutta A.K, "Wastewater Treatment", Oxford - IBH Publication, 1995.
2. Jr.Eckenfelder W.W. , "Industrial Water Pollution Control", McGraw Hill Book Company,New Delhi, 2000.
3. Patwardhan A.D, "Industrial Wastewater Treatment", Prentice Hall of India, New Delhi 2010.

REFERENCES

1. Shen T.T, "Industrial Pollution Prevention", Springer, 1999.
2. Stephenson R.L, Blackburn, J.B "Industrial Wastewater Systems Handbook",Lewis Publisher, New York, 1998
3. Freeman H M, "Industrial Pollution Prevention Handbook", McGraw Hill Inc., New Delhi,1995.
4. Bishop P.L, "Pollution Prevention: Fundamental & Practice", McGraw Hill, 2000.
5. Pandey, "Environmental Management", Vikas Publications, 2010.
6. "Industrial Wastewater Management, Treatment and Disposal", (WEF - MOP - FD3) McGrawBHill, 2008.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2					2			2			3	
CO2	2	3	2	2		2						2		3
CO3	2	2		2		2	2						3	
CO4	3	2	3				2	2		2		2	3	3
CO5	3	2	3				2	2		2			3	

COURSE CODE	COURSE TITLE	L	T	P	C
UCE2826	WATER RESOURCES ENGINEERING	3	0	0	3

COURSE OBJECTIVES:

- The student is exposed to the different phases in Water Resources viz planning, collection of relevant data on water resources and also on National Water Policy. Reservoir planning, management and economic analysis aspects are covered in detail.

UNIT I GENERAL 9

Water resources survey – Water resources of India and Tamilnadu – Description of water resources planning – Economics of water resources planning, physical and socio economic data – National Water Policy – Collection of meteorological and hydrological data for water resources development.

UNIT II NETWORK DESIGN 9

Hydrologic measurements – Analysis of hydrologic data – Hydrologic station network – Station network design – Statistical techniques in network design.

UNIT III WATER RESOURCE NEEDS 9

Consumptive and non-consumptive water use - Estimation of water requirements for irrigation, for drinking and navigation - Water characteristics and quality – Scope and aims of master plan- Concept of basin as a unit for development - Water budget and development plan.

UNIT IV RESERVOIR PLANNING AND MANAGEMENT 9

Reservoir - Single and multipurpose – Multi objective - Fixation of Storage capacity –Strategies for reservoir operation - Sedimentation of reservoirs - Design flood-levees and flood walls - Channel improvement.

UNIT V ECONOMIC ANALYSIS 9

Estimation of cost and Evaluation of Benefits - Discount rate - Discounting factors – Discounting techniques – Computer Applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course the students will be able to:

CO1: Demonstrate understanding on the different phases in Water Resources viz planning.
CO2: Analyse the Hydrological data using Statistical techniques in network design.
CO3: Develop the water budget and plan for a Basin level.
CO4: Outline the strategies for reservoir operation.
CO5: Evaluate the cost and Benefits of Water Resources projects.

TEXT BOOKS

1. Linsle R.K, Franzini J.B, "Water Resources Engineering", McGraw-Hill Inc, 2000.
2. Douglas J.L, Lee R.R, "Economics of Water Resources Planning", Tata McGraw-Hill nc. 2000.
3. Duggal K.N, Soni V "Elements of Water Resources Engineering", New Age International Publishers,1996.

REFERENCES

1. Chaturvedi, M.C, "Water Resources Systems Planning and Management", Tata McGraw- Hill Inc., New Delhi, 1997.
2. Goodman Alvin, S., "Principles of Water Resources Planning", Prentice-Hall, 1984.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2									2	3	
CO2	3	2				3							2	
CO3	3	3	3				2	2	2	2			2	2
CO4	3	2					3			2	2			
CO5	3	2	2	3		2			2	2		2	3	2

COURSE CODE	COURSE TITLE	L	T	P	C
UCE2522	**ALTERNATIVE BUILDING MATERIALS AND TECHNOLOGIES**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

- Understand the concept of energy, environmental and cost effectiveness in buildings.
- Identify characteristics of alternate materials.
- Recognize the technologies applied in building construction.
- Understand the masonry strength concepts.
- Recognize equipment's required for manufacture of alternate building materials.

UNIT I INTRODUCTION 9

Energy in building materials-Environmental issues concerned to building materials-Global warming and construction industry. Environmentally friendly and cost-effective building technologies-Requirements for building of different climatic regions-Traditional building methods and vernacular architecture.

UNIT II ALTERNATIVE BUILDING MATERIALS 9

Characteristics of building blocks for walls-Stones and Laterite Blocks-Bricks and hollow clay blocks-Concrete Blocks-Stabilized blocks: Mud Blocks-Steam Cured Blocks-Fal-G Block-sand Stone Masonry Block.

UNIT III ALTERNATIVE BUILDING TECHNOLOGIES 9

Alternative for wall construction-Ferrocement and ferro concrete building components- Composite beam panel roofs-Masonry vaults and domes-Alternative roofing systems- Filler slabs.

UNIT IV STRUCTURAL MASONRY 9

Compressive strength of masonry Elements-Factors affecting compressive Strength-Strength of units, prisms/wallet's and walls-Effect of brick work bond on strength-Bond strength of masonry: Flexure and shear, Elastic properties of masonry materials and masonry.

UNIT V EQUIPMENT FOR PRODUCTION OF ALTERNATIVE MATERIALS 9

Machines for manufacture of Concrete-Equipment for production of stabilized blocks-Moulds and methods of production of precast elements.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Demonstrate understanding on properties (physical, structural) of most common and advanced building materials.
CO2: Explain typical and potential applications of alternative building materials.
CO3: Discuss relationship between material properties and structural form.
CO4: Identify crucial problem areas in manufacture and applications of building materials.
CO5: Evaluate the importance of experimental verification of material properties.

TEXTBOOKS

1. Arnold W. Hendry: "Structural Masonry", (Chapters1-5), Palgrave Macmillan, 2 nd Edition, 2013.
2. Jagadish.K. S: "Strucutral Masonry", published by I K International Publishing House Pvt. Ltd. 2015

REFERENCES

1. Jagadish.K.S, & quot; Alternative Building Materials Technology", New Age International, 2007.
2. Gambhir. M.L., & Neha Jamwal., "Building Materials, products, properties and systems", Tata McGraw Hill Educations Pvt. Ltd, New Delhi, 2012.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	3	2	1	2	1	2	1		1	1	2

CO2	2	3	2	3	1	2	3	1	2	1		2	2	2
CO3	2	3	3	3	2	2	2	1	2	3		2	1	2
CO4	2	3	2	3	2	2	2	1	2	3		1	2	3
CO5	3	3	2	3	3	2	3	1	2	2		3	3	2

COURSE CODE	COURSE TITLE	L	T	P	C
UCE2041	**GREEN BUILDING DESIGN**	**3**	**0**	**0**	**3**

OBJECTIVES:

- To introduce various components of green building including alternative materials and technologies used in construction.
- To learn about thermal comfort and the concept of using solar energy in building design.

UNIT I ENVIRONMENTAL IMPLICATIONS OF BUILDINGS 9

Energy use, carbon emissions, water use; Building materials: sources, methods of production and environmental Implications; Embodied Energy in Building Materials; Transportation Energy for Building Materials; Maintenance Energy for Buildings.

UNIT II ALTERNATIVE BUILDING TECHNOLOGIES & MATERIALS 9

Framed Construction, Masonry Construction, Alternative building technologies; Resources for Building Materials, Recycling of Industrial and Buildings Wastes; Biomass Resources for buildings.

UNIT III THERMAL COMFORTS IN BUILDING 9

Thermal Comfort in Buildings- Issues; Heat Transfer Characteristic of Building Materials and Building Techniques. Incidence of Solar Heat on Buildings-Implications of Geographical Locations.

UNIT IV SOLAR ENERGY IN BUILDINGS 9

Utility of Solar energy in buildings concepts of Solar Passive Cooling and Heating of Buildings. Low Energy Cooling. Case studies of Solar Passive Cooled and Heated Buildings.

UNIT V GREEN COMPOSITES FOR BUILDINGS 9

Concepts of Green Composites; Water Utilization in Buildings, Low Energy Approaches to Water Management. Management of Sullage Water and Sewage; Green Cover and Built Environment.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able to

CO1: Evaluate the embodied energy of common building materials and its implications on environment.

CO2: Apply alternative building technologies and use of recycled waste materials in building construction

CO3: Design buildings for providing good thermal comfort in different geographical locations.

CO4: Design buildings by adopting different solar passive cooling and heating techniques

CO5: Select appropriate methods for the management of water and wastewater in buildings.

TEXTBOOKS:

1. Jagadish K.S, Venkataramareddy B.U, Nanjundarao K.S, “Alternative Building Materials and Technologies”. New Age International, 2007.
2. Ursula Eicker, “Low Energy Cooling for Sustainable Buildings”, John Wiley and Sons Ltd, 2009.
3. Teri P, “Sustainable Building Design Manual”, Vol 1 and 2, Teri, New Delhi, 2004.

REFERENCES:

1. Osman Attmann, “Green Architecture Advanced Technologies and Materials” . McGraw Hill, 2010.
2. Jerry Yudelson,” Green Building Through Integrated Design” . McGraw Hill, 2009.
3. Marian Keeler,Prasad Vaidya, “Fundamentals of Integrated Design for Sustainable Building”, Bill Burke,2016.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	1		1	3					1
CO2	2	1	1	1		1	3					1
CO3	2	1	3	1		1	2					1
CO4	2	1	3	1		1	2					1
CO5	2	1	3	1		1	3					1

COURSE CODE	COURSE TITLE	L	T	P	C
UCE2042	**SUSTAINABLE INFRASTRUCUTRE**	**3**	**0**	**0**	**3**

OBJECTIVES:

- To understand and explain the concepts of infrastructure, strategies for successful infrastructure project implementation, green building and sustainability concept and sustainable development of infrastructure

UNIT I AN OVERVIEW OF BASIC CONCEPTS RELATED TO INFRASTRUCTURE 9

Introduction to Infrastructure, an overview of the Power Sector in India., an Overview of the Water Supply and Sanitation Sector in India., an overview of the Road, Rail, Air and Port Transportation Sectors in India. , an overview of the Telecommunications Sector in India. , an overview of the Urban Infrastructure in India, an overview of the Rural Infrastructure in India, an Introduction to Special Economic Zones, Organizations and layers in the field of Infrastructure, The Stages of an Infrastructure Project Lifecycle., an overview of Infrastructure Project Finance.

UNIT II CHALLENGES TO SUCCESSFUL INFRASTRUCTURE PLANNING AND IMPLEMENTATION 9

Mapping and Facing the Landscape of Risks in Infrastructure Projects, Economic and Demand Risks: The Case study for Political Risks, Socio-Environmental Risks, Cultural Risks in International Infrastructure Projects, Legal and Contractual Issues in Infrastructure, Challenges in Construction and Maintenance of Infrastructure.

UNIT III GREEN BUILDING CONCEPTS 9

Green projects in smart cities, sustainability – green building – Rating system – Energy efficient building – energy saving systems.

UNIT IV SUSTAINABLE DEVELOPMENT 9

Definitions and principles of Sustainable Development - History and emergence of the concept of Sustainable Development - Environment and Development linkages- Globalization and environment – Millennium Development Goals: Status (global and Indian) - Impacts on approach to development policy and practice in India, future directions.

UNIT V SUSTAINABLE DEVELOPMENT OF INFRASTRUCTURE 9

Information Technology and Systems for Successful Infrastructure Management, - Innovative Design and Maintenance of Infrastructure Facilities, Infrastructure Modeling and Life Cycle Analysis Techniques, Capacity Building and Improving the Governments Role in Infrastructure Implementation, An Integrated Framework for Successful Infrastructure Planning and Management - Infrastructure Management Systems and Future Directions.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Demonstrate understanding on the basic concepts related to sustainable infrastructure Projects.
CO2: Identify the role of private sector in infrastructure growth.
CO3: Discuss the green building concept.
CO4: Evaluate the concept and socio-economic policies of Sustainable Development.
CO5: Implement the sustainable development of Infrastructure.

TEXTBOOK:

- Hudson, Haas, Uddin, "Infrastructure management: integrating design, construction, maintenance, rehabilitation, and renovation", McGraw Hill, 2013.

REFERENCES:

1. Ganesha Somayaji, Sakarama Somayaji, "Environmental Concerns and Sustainable
2. development: Some perspectives from India", Editors: publisher TERI Press
3. James H. Weaver, Michael T. Rock, Kenneth Kustere, "Achieving Broad-Based Sustainable Development: Governance, Environment, and Growth with Equity", Kumarian Press, West Hartford, CT. PublicationYear,1997.
4. Kerry Turner R, "Sustainable Environmental Management, Principles and Practice" Publisher: Belhaven Press, ISBN:1852930039.
5. N.Munier. N, "Introduction to Sustainability", Springer 2005

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	3	2	1	2	1	2	1		1
CO2	2	3	2	3	1	2	3	1	2	1		2
CO3	2	3	3	3	2	2	2	1	2	3		2
CO4	2	3	2	3	2	2	2	1	2	3		1
CO5	3	3	2	3	3	2	3	1	2	2		3

COURSE CODE	COURSE TITLE	L	T	P	C
UCE2044	ENVIRONMENTAL IMPACT ASSESSMENT	3	0	0	3

OBJECTIVE:

- To impart the knowledge and skills to identify, assess and mitigate the environmental and social impacts of developmental projects

UNIT I INTRODUCTION 9

Impacts of Development on Environment – Rio Principles of Sustainable Development- Environmental Impact Assessment (EIA) – Objectives – Historical development – EIA Types – EIA in project cycle –EIA Notification and Legal Framework

UNIT II METHODOLOGIES 9

Methods of EIA –Check lists – Matrices – Networks – Cost-benefit analysis – Analysis of Alternatives

UNIT III PREDICTION AND ASSESSMENT 9

Assessment of Impact on land, water and air, noise, social, cultural flora and fauna; Mathematical models; public participation – Rapid EIA

UNIT IV ENVIRONMENTAL MANAGEMENT PLAN 9

Plan for mitigation of adverse impact on water, air and land, water, energy, flora and fauna -Environmental Monitoring Plan – EIA Report Preparation – Public Hearing-Environmental Clearance

UNIT V CASE STUDIES 9

EIA case studies pertaining to Infrastructure Projects – Roads and Bridges – Mass Rapid Transport Systems - Airports - Dams and Irrigation projects - Power plants

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students completing the course will have ability to

CO1: Demonstrate understanding on the framework of Environmental Impact Assessment, historical development and Rio Principles.
CO2: Identify appropriate methodologies for performing an Environmental Impact Assessment. carry out scoping and screening of developmental projects for environmental assessments
CO3: Assess and predict the impact of developmental activities on various environmental matrices using mathematical models
CO4: Explain different methodologies for environmental impact prediction and assessment. Prepare and evaluate environmental impact assessment reports
CO5: Study and analyze EIA case studies for various infrastructure projects.

TEXTBOOKS:

1. Canter, R.L, "Environmental impact Assessment", 2nd Edition, McGraw Hill Inc, New Delhi,1995.
2. Ramachandran, S. "Environmental Impact Assessment", Airwalk Publications, Chennai, 2019.
3. Peter Morris, Riki Therivel, "Methods of Environmental Impact Assessment", Routledge Publishers,2019.

REFERENCES:

1. Glasson, J., Therivel, R., “Introduction to Environmental Impact Assessment”, 5th Edition, Routledge, UK, 2019
2. Becker, H.A, Frank Vanclay, “The International handbook of social impact assessment conceptual and methodological advances”, Edward Elgar Publishing,2003.
3. Barry Sadler and Mary McCabe, “Environmental Impact Assessment Training Resource Manual”, United Nations Environment Programme,2002.
4. Ministry of Environment and Forests EIA Notification and Sectoral Guides, Government of India, New Delhi, 2010.H.A. Becker, Frank Vanclay, “The International handbook of social impact assessment conceptual and methodological advances”, Edward Elgar Publishing,2003.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3						2				2	
CO2	3						2		2	2	2	
CO3	3	2	2		2		2	2		2		
CO4	3		3				2	2	2	2		
CO5							2		2	2		

COURSE CODE	COURSE TITLE	L	T	P	C
UCE2043	**INTEGRATED WATER RESOURCES MANAGEMENT**	**3**	**0**	**0**	**3**

OBJECTIVES:

- To introduce the students to the interdisciplinary analysis of water and conceptual design of intervention strategies.
- To develop a knowledge-base on capacity building on IWRM.

UNIT I IWRM FRAMEWORK 9

Definition – Objectives – Principles - Evolution of IWRM - IWRM relevance in water resources management – Paradigm shift: Processes and prospective outcomes

UNIT II CONTEXTUALIZING IWRM 9

UN formulations - SDG goals - IWRM in Global, Regional and Local water partnership – Institutional transformation - Bureaucratic reforms - Inclusive development

UNIT III EMERGING ISSUES IN WATER MANAGEMENT 9

Emerging Issues -– Drinking water management in the context of climate change - IWRM and irrigation - Flood – Drought – Pollution – Linkages between water, health
and poverty

UNIT IV IWRM AND WATER RESOURCES DEVELOPMENT IN INDIA 9

Rural Development - Ecological sustainability- -Watershed development and conservation -Ecosystem regeneration – Wastewater reuse - Sustainable livelihood - Food security

UNIT V ASPECTS OF INTEGRATED DEVELOPMENT 9

Capacity building - Conceptual framework of IWRM – Problems and policy issues – Solutions for effective integrated water management - Case studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1: Outline the objectives, principles and evolution of integrated water resources management.

CO2: Demonstrate understanding on contextualizing of integrated water resources management

CO3: Identify emerging issues in water management, flood, drought, pollution and poverty.

CO4: Outline the water resources development in India and wastewater reuse.

CO5: Apply the principles of integrated development of water management in context based situations

TEXTBOOKS:

1. Mollinga P et al., "Integrated Water Resources Management", Water in South Asia Volume I, Sage Publications, 2006.
2. Sithamparanathan, Rangasamy, A, Arunachalam, N, "Ecosystem Principles and Sustainable Agriculture", Scitech Publications (India) Pvt.Lt, Chennai, 1999.

REFERENCES:

1.Cech Thomas, V, "Principles of Water Resources: History, Development, Management and Policy", John Wiley and Sons Inc., New York. 2003.
2. Murthy, J.V.S, "Watershed Management in India", Wiley Eastern Ltd., New York, 1995.
3. Dalte, S.J.C, "Soil Conservation and Land Management", International Book Distribution, India, 1986.
4. Chaturvedi, M.C, "Water Resources Systems Planning and Management", Tata McGraw- Hill Inc., New Delhi, 1997.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2									2
CO2	3	2	2			1						
CO3	3	2				2						
CO4	3		1			2	2					
CO5	3	3	2				2					2

COURSE CODE	COURSE TITLE	L	T	P	C
UCE2046	**AIR POLLUTION AND CONTROL ENGINEERING**	**3**	**0**	**0**	**3**

OBJECTIVE:

To impart knowledge on the principle and design of control of Indoor/ particulate/gaseous air pollutant and its emerging trends.

UNIT I AIR QULALITY **9**

Structure and composition of Atmosphere – Definition, Scope and Scales of Air Pollution– Sources and classification of air pollutants and their effect on human health, vegetation, animals, property, aesthetic

value and visibility- Ambient Air Quality and Emission standards –Ambient and stack sampling and Analysis of Particulate and Gaseous Pollutants.

UNIT II ATMOSPHERIC DISPERSION OF AIR POLLUTANT 8

Effects of meteorology on Air Pollution - Fundamentals, Atmospheric stability, Inversion, Wind profiles and stack plume patterns- Atmospheric Diffusion Theories – Dispersion models, Plume rise

UNIT III CONTROL OF PARTICULATE CONTAMINANTS 9

Gas Particle Interaction – Working principle, Design and performance equations of Gravity Separators, Centrifugal separators Fabric filters, Particulate Scrubbers, Electrostatic Precipitators – Operational Considerations- Factors affecting Selection of Control Equipment

UNIT IV CONTROL OF GASEOUS CONTAMINANTS 10

Working principle, Design and performance equations of absorption, Adsorption, condensation, Incineration, Bio scrubbers, Bio filters – Process control and Monitoring – Operational Considerations- Factors affecting Selection of Control Equipment –CO2 capturing.

UNIT V INDOOR AIR QUALITY MANAGEMENT 9

Sources types and control of indoor air pollutants, sick building syndrome types – Sources and Effects of Noise Pollution – Measurement – Standards–Control and Preventive measures

TOTAL PERIODS: 45

COURSE OUTCOMES:

On successful completion of this course, the students will be able to demonstrate understanding on:

CO1: Apply the knowledge of atmospheric chemistry and characteristics of air pollutant to describe the effects of air pollution

CO2: Apply the knowledge of mathematics, science and engineering fundamentals to understand the concept of meteorology, air pollution dispersion and Gaussian plume dispersion model

CO3: Plan and design of unit processes and unit operations for the particulate pollutant control equipment

CO4: Plan and design of unit processes and unit operations for control of gaseous pollutant by due consideration of sources of emission

CO5: Demonstrate understanding on the source of indoor air pollution, effects and control methods as well as to identify the source of noiseand select suitable method for measuring and control of noise pollution

TEXTBOOKS:

1. Lawrence K. Wang, Norman C. Pareira, Yung Tse Hung, “Air Pollution Control Engineering”, Tokyo, 2012.
2. Noel de Nevers, “Air Pollution Control Engineering”, Mc Graw Hill, New York, 2016.
3. Anjaneyulu. Y, “Air Pollution and Control Technologies”, Allied Publishers (P) Ltd., India 2019.
4. Rao M.N, Rao, H.V.N, “Air Pollution Control”, Tata-McGraw-Hill, New Delhi, 2017.

REFERENCES:

1. Cooper, C.D, Alley, F.C, “Air Pollution Control A Design Approach”, Waveland Press, Inc, Illinois, USA, 2010.
2. David Liu, H.F, Bela Liptak G, “Air Pollution”, Lweis Publishers, 2018.
3. Schnelle, K.B.., Dunn, R. F., Ternes, M.E, “ Air Pollution Control Technology Handbook” , 2nd Edition, Routledge, U.K., 2017.

CO – PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2			2		3	2					2
CO2	3	3		2	3							2
CO3	3	2	3	2				2		2		2
CO4	3	2	3	2				2		2		2
CO5	2			1		3	2					3

Mapping of courses – B. Tech Chemical

Course	Sustainable Development Goals																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Air Pollution and Control			✓								✓		✓				
Basic Industrial Biotechnology								✓	✓								
Fuels and Combustion							✓		✓				✓				
Food Technology		✓	✓					✓	✓						✓		
Wastewater Treatment			✓			✓								✓			
Energy, Environment and Impact Assessment			✓			✓	✓	✓	✓		✓		✓	✓	✓		✓
Synthesis and Applications of Nanomaterials						✓			✓			✓					
Carbon Capture Utilization and Storage							✓						✓		✓		
Drugs and Pharmaceutical Technology								✓	✓								✓
Solid waste Management			✓								✓			✓			
Bio-Energy Technology				✓			✓	✓	✓			✓	✓		✓		
Green Chemistry and Engineering			✓				✓	✓	✓				✓		✓		
Fuel Cells							✓	✓	✓								
Environmental Engineering			✓			✓							✓		✓	✓	✓
Alternative Fuels							✓	✓	✓		✓	✓	✓				
Frontiers of Chemical Engineering							✓	✓	✓								

Course	Sustainable Development Goals																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Petroleum Refining and Petrochemicals				✓				✓	✓								
Energy Technology							✓				✓	✓	✓				

COURSE CODE	COURSE TITLE	L	T	P	C
UCH2521	AIR POLLUTION AND CONTROL	3	0	0	3

COURSE OBJECTIVE:

This course is aimed to understand the sources, characteristics and effects of air pollution and their control methodology.

UNIT I AIR POLLUTION 9

Air Pollution: Sources and Effects. Classifications: Natural and Artificial; Primary and Secondary. Sources of air pollution: Stationary and mobile sources. Effects of Air pollutants on humans, materials and vegetation. Global effects of air pollution. Green House effect, Heat Islands, Acid Rains, Ozone Holes.

UNIT II AIR QUALITY MONITORING MANAGEMENT 9

Ambient Air Sampling: sampling procedures for collection of gases and particulates, High Volume Sampler. Stack monitoring: Sampling Techniques for Stack gases. Analysis of Air Pollutants: SOx, NOx, CO, Hydrocarbons and Particulate matter. Air quality standards and Emission standards.

UNIT III METEOROLOGY AND PLUME DISPERSION 9

Properties of atmosphere: Temperature, Pressure and Wind forces. Influence of Meteorological phenomena on Air Quality. Temperature lapse rates and Atmospheric Stability. Wind velocity and turbulence. Plume behaviour. Wind rose diagrams. Dispersion theories and models, stack height, plume rise.

UNIT IV AIR POLLUTION CONTROL METHODS 9

Source correction methods: Raw material changes, Process Changes and Equipment modifications, Particulate control equipments: Settling Chambers, Centrifugal separators, Fabric filters Wet scrubbers and Electrostatic precipitators. Collection efficiency and design problems. General Methods of Control of Gaseous emissions: Absorption, Adsorption and Combustion. Control of NOx and SOx emissions.

UNIT V AIR POLLUTION IN INDUSTRIES AND AUTOMOBILES 9

Air pollution from major industrial operations: Mining and mineral processing, Cement manufacturing, Petroleum refinery, Metallurgical operations Thermal power plants. Air Pollution due to Automobiles: Emissions from automobiles, formation of photochemical smog, Combustion, Air-Fuel ratio, Control of Exhaust emissions.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the types of air pollutants, their sources and effects.

CO2: Describe sampling techniques for common air pollutants such as SOx, NOx, hydrocarbons and particulate matter and apply it in air quality monitoring.

CO3: Analyze the plume behavior for different atmospheric stability conditions and discuss the theories of

stack plume dispersion.
CO4: Calculate the efficiency of particulate matter and common gaseous pollution control equipment.
CO5: Outline the air pollution from major industries like mining, cement, petroleum and metallurgical industries, and also from automobiles.

TEXT BOOKS:

1. Rao M.N., and Rao H. V. N., Air Pollution Control, Tata McGraw Hill, New Delhi, 2007.
2. Anjaneyulu, D., "Air Pollution and Control Technologies", Allied Publishers, Mumbai, 2002.

REFERENCES:

1. R.K Trivedy and P.K Goel, An Introduction to Air Pollution, 2009, BS Publications, Hyderabad.
2. Heumann. W.L., "Industrial Air Pollution Control Systems", McGraw Hill, New Yark, 1997.
3. Rao, C.S. Environmental Pollution Control Engineering, Wiley Eastern Ltd., New Delhi, 1996.
4. Mahajan, S.P., "Pollution Control in Process Industries", Tata McGraw Hill, New Delhi, 1991.

CO-PO-PSO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2					3	3	1				1		1
2	2					3	3	1				1		1
3	2					3	3	1				1		1
4	2					3	3	1				1		1
5	2					3	3	1				1		1

COURSE CODE	COURSE TITLE	L	T	P	C
UCH2522	BASIC INDUSTRIAL BIOTECHNOLOGY	3	0	0	3

COURSE OBJECTIVE:

The course aims to make the students aware of the overall fermentation technology and understand the principles and biochemical pathways for the production of commercially important bio-products.

UNIT I INTRODUCTION TO INDUSTRIAL BIOPROCESS 9

Fermentation- Bacterial, Fungal and Yeast, Biochemistry of fermentation. Types of media, Basic concepts of upstream and downstream processing in Bioprocess, Process flow sheeting – block diagrams, pictorial representation. Bioprocess strategies in Plant Cell and Animal Cell culture, monitoring contamination.

UNIT II PRODUCTION OF ORGANIC ACIDS, AMINO ACIDS AND ALCOHOLS 9

Production of commercially important Primary metabolites: Organic Acids – Citric acid, Lactic acid, Acetic acid, Itaconic acid, Kojic acid; Amino Acids – L-Glutamic acid, L-Lysine, L-Tryptophan and Alcohols – Ethanol, Butanol, Glycerol; Biosynthetic Pathways and Feedback Mechanisms.

UNIT III PRODUCTION OF ANTIBIOTICS, VITAMINS AND STEROIDS 9

Production processes for various classes of secondary metabolites: Antibiotics – β-Lactam Antibiotics Penicillin, Cephalosporin, Tetracycline; Vitamins – Vitamin B12, Riboflavin, β-Carotene and Alkaloids; Biosynthetic Pathways and Feedback Mechanisms.

UNIT IV PRODUCTION OF ENZYMES, BIOFUELS, DIETARY SUPPLEMENTS 9

Production of Enzymes, Bio pesticides, Bio fertilizers, Bio preservatives, Biopolymers, Biodiesel,

Bioethanol, Biogas. Cheese, Beer, Single Cell Proteins – Bacterial, Yeast, Algal & Mushroom culture, Bioremediation, Economic Aspects.

UNIT V PRODUCTION OF RECOMBINANT BIOPRODUCTS 9

Production of recombinant proteins having therapeutic and diagnostic applications, Monoclonal antibodies, vaccines, Human Growth Factor, Insulin, Tumor Suppressor Proteins, Future Aspects.

TOTAL:45 PERIODS

COURSE OUTCOMES:

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

CO1: Explain the basic concepts of upstream and downstream processing in Industrial bioprocess.

CO2: Summarize the production processes for primary metabolites.

CO3: Summarize the production processes for secondary metabolites.

CO4: Elaborate on the production processes for bioproducts such as enzymes, biofuels, and dietary supplements.

CO5: Elaborate on the production processes for recombinant bioproducts.

TEXT BOOKS:

1. Casida, L.E. "Industrial Microbiology", New Age International (P) Ltd, 1968.
2. Cruger,Wulf and Anneliese Crueger, "Biotechnology: A Textbook of Industrial Microbiology", IInd Edition, Panima Publishing, 2000.

REFERENCES:

1. Prescott, S.C. and Cecil G. Dunn, "Industrial Microbiology", Agrobios (India), 2005.
2. Moo-Young, Murrey, "Comprehensive Biotechnology", 4 Vols. Pergamon Press,(An Imprint of Elsevier) 2004.
3. C.F.A Bryce and EL.Mansi, Fermentation microbiology & Biotechnology, 1999.
4. K.G.Ramawat and Shaily Goyal, Comprehensive Biotechnology, 2009, S.Chand publications.

CO-PO-PSO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2									2		2	3	2
2	2									2		2	3	2
3	2									2		2	3	2
4	2									2		2	3	3
5	2									2		2	3	2

COURSE CODE	COURSE TITLE	L	T	P	C
UCH2523	FUELS AND COMBUSTION	3	0	0	3

COURSE OBJECTIVE:

The course is aimed to understand different types of fuel and fuel analysis techniques that assist the students to choose most convenient fuel and suitable equipment for a process involving combustion.

UNIT I CLASSIFICATION AND PROPERTIES OF FUELS 9

Types and characteristics of fuels. Determination of properties of fuels. Fuel Analysis, comparative study of Solid, liquid and gaseous fuels. Gross and net calorific values, Bomb Calorimetry and empirical equations for estimation of calorific value.

UNIT II SOLID FUELS 8

Origin of coal, Ranking of coal, Washing, cleaning and storage of coal, Renewable Solid Fuels, selection of

coal for different industrial applications, carbonization of coal.

UNIT III LIQUID FUELS 8

Origin of crude oil, composition of crude petroleum, classification of crude petroleum. Removal of salt from crude oil, processing of crude petroleum. Fractionation distillation, Cracking, Hydrotreatment and Reforming.

UNIT IV GASEOUS FUELS 8

Rich and lean gas, Wobbe index, Natural gas, Dry and wet natural gas, Foul and sweet NG-LPG-LNG-CNG-Methane-Producer Gas-Water gas, Coal Gasification-Gasification Efficiency.

UNIT V COMBUSTION AND COMBUSTION EQUIPMENT 12

General principles of combustion, types of combustion processes, combustion calculations, air-fuel ratio, Excess air calculations. Grate firing and pulverized fuel firing system, Fluidized bed combustion, Circulating fluidized bed boiler, Burners, Factors affecting burners and combustion.

TOTAL:45 PERIODS

COURSE OUTCOMES:

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

CO1: Classify types of fuels and outline the various properties of liquid, solid and gaseous fuels.

CO2: Discuss the origin, maintenance, and application of coal in various industries.

CO3: Explain the origin, composition, and steps involved in the processing of crude oil.

CO4: Discuss the various gaseous fuel availability and compare their applications.

CO5: Perform combustion calculations and compare the performance of combustion equipments.

TEXT BOOKS:

1. Kenneth K.K., Principles of Combustion, 2nd ed., Wiley Publications, USA, 2012.
2. Sarkar S., Fuels and combustion, 3rd ed., Universities Press, India, 2009.

REFERENCES:

1. Phillips H.J., Fuels-solid, liquid and gases-Their analysis and valuation, 1st ed., Foster Press, USA, 2010
2. S.P.Sharma and C. Mohan, Fuels and Combustion, Tata McGraw Hill, 2004.
3. S. N. Saha, Fuel Combustion Energy Technology, Dhanpat Rai Pub. Co, 2008.
4. Stephen R Turns, An introduction to combustion: Concept and applications, Tata Mc. Graw Hill, 3rd ed., 2012.

CO-PO-PSO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2					1								1
2	2						2							1
3	2						2	1						1
4	2	2					2	1						1
5	2	2	2	2		1	2	1	3	3	2	2	2	1

COURSE CODE	COURSE TITLE	L	T	P	C
UCH2526	FOOD TECHNOLOGY	3	0	0	3

COURSE OBJECTIVE:

To enable the students to learn to design processing equipments for Food Industries.

UNIT I AN OVERVIEW 5

General aspects of food industry; world food needs and Indian situation.

UNIT II FOOD CONSTITUENTS, QUALITY AND DERIVATIVE FACTORS 14

Constituents of food; quality and nutritive aspects; food additives; standards; deteriorative factors and their control.

UNIT III GENERAL ENGINEERING ASPECTS AND PROCESSING METHODS 9

Preliminary processing methods; conversion operations, Non thermal preservation process.

UNIT IV FOOD PRESERVATION METHODS 12

Preservation by heat and cold; dehydration; concentration; drying irradiation; microwave heating; sterilization and pasteurization; fermentation and pickling; packing methods.

UNIT V PRODUCTION AND UTILISATION OF FOOD PRODUCTS 14

Cereal grains; pulses; vegetables; fruits; spices; fats and oils; bakery; confectionery and chocolate products; soft and alcoholic beverages; dairy products; meat; poultry and fish products.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Acquire the general aspects of the food industry and its need in India and the world.

CO2: Outline the constituents of food material and discuss the quality and control measures on their deteriorative factors.

CO3: Describe the necessity of preliminary food processing methods and preservative operations to minimize food deterioration.

CO4: Differentiate various food preservative techniques and their usage in the food industry.

CO5: Summarize the production methodologies adapted for different types of common food products and discuss their utilization in the world.

TEXT BOOKS:

1. Heid J.L. Joslyn M.A., Fundamentals of Food Processing Operation, The AVI publishing Co., West port 1967.
2. Potter N.N., Food Science, The AVI publishing Co., Westport, 1963.

REFERENCES:

1. Heldman D.R., Food Process Engineering, The AVI publishing co., 1975.
2. Charm S.E., The Fundamentals of Foods Engineering, The AVI Publishing Co., Westport, 1963.

CO-PO-PSO Mapping

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1				2		2					3	3		1
2						2	3					3		1
3	1				1		3							2
4	2						3					2		2
5	2											2		1

COURSE CODE	COURSE TITLE	L	T	P	C
UCH2527	ENVIRONMENTAL ENGINEERING	3	0	0	3

COURSE OBJECTIVES:

To provide technical expertise in Environmental Engineering which will enable them to have a career and professional accomplishment in the public or private sector

UNIT I ENVIRONMENT AWARENESS 9

Environment – friendly chemical Process; Hazard and risk analysis; Environmental Audit Consequences of Population Growth; Energy consumption and demand.

UNIT II CHEMICAL ENGINEERING PROCESSES 9

Unit Operations – application of - Abatement of water pollution; Current strategies to control air pollution; Disposal of solid wastes

UNIT III RECYCLING METHODOLOGY 9

Economic recovery and recycling of waste; Transport fuel-Biodiesel for a cleaner environment.

UNIT IV CLEAN TECHNOLOGY 9

Towards Eco-friendly products of chemical industry; Pesticides–Their transfer and Transformation in the environment, Biological and electrochemical technology for effluent treatments.

UNIT V POLLUTION PREVENTION 9

Mass exchange network synthesis for pollution control and minimization Implications of environmental constraints for process design, policies for regulation of environmental impacts, Concept of common effluent treatment; Environmental legislations, Role of Government and Industries.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: List the consequences of population growth with respect to the environment and energy.
CO2: Explain the application of chemical engineering processes in abatement of Environmental pollution.
CO3: Determine the recycling methodologies and their economic recovery for a cleaner environment.
CO4: Outline on clean technologies for effluent treatment.
CO5: Analyze on the role of government, Industries and mass exchange network synthesis in pollution prevention.

TEXT BOOKS:

1. Rao, C.S Environmental Pollution Control Engineering, Wiley- Eastern Ltd. 1991.
2. Peavy H.S. Rowe D.R., and George Technologious, Environmental Engineering, McGraw Hill Book Company, Ny, 1985.

REFERENCES:

1. Coulson, J.M. Richardson, J.F and R.K Sinnott, Chemical Engineering Vol. 6, Pergomon Press, 1989.
2. Gilbert M.Mastrs, Introduction to Environmental Engineering and Science, Prentice - Hall of India, New Delhi, 1994.
3. Wahi S.K., Agnihotri A.K and Sharmma J.S (Editors) Environmental Management in Petroleum Industry, Wiley Eastern Ltd., New Delhi 1996.
4. Paul L Bishop, Pollution Prevention Fundamentals and Practice, McGraw Hill, International 2000.

CO-PO-PSO Mapping

COs	Pos												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	2					3	3	1				1		1
2	2					3	3	1				1		1
3	2					3	3	1				1		1
4	2					3	3	1				1		1
5	2					3	3	1				1		1

COURSE CODE	COURSE TITLE	L	T	P	C
UCH2621	**WASTEWATER TREATMENT**	**3**	**0**	**0**	**3**

COURSE OBJECTIVE:

To focus on the wastewater transport system and the theory and design technique for the wastewater treatment process.

UNIT I WASTE WATER TREATMENT AN OVERVIEW 9

Terminology – Regulations – Health and Environment Concerns in wastewater management – Constituents in waste water inorganic – Organic and metallic constituents.

UNIT II PROCESS ANALYSIS AND SELECTION 9

Components of wastewater flows – Analysis of Data – Reactors used in wastewater treatment – Mass Balance Analysis – Modeling of ideal and non-ideal flow in Reactors – Process Selection.

UNIT III CHEMICAL UNIT PROCESSES 9

Role of unit processes in wastewater treatment chemical coagulation – Chemical precipitation for improved plant performance chemical oxidation – Neutralization – Chemical Storage.

UNIT IV BIOLOGICAL TREATMENT 9

Overview of biological Treatment – Microbial metabolism – Bacterial growth and energetics – Aerobic biological oxidation – Anaerobic fermentation and oxidation – Trickling filters – Rotating biological contractors – Combined aerobic processes – Activated sludge film packing.

UNIT V ADVANCED WASTEWATER TREATMENT 9

Technologies used in advanced treatment – Classification of technologies Removal of Colloids and suspended particles – Depth Filtration – Surface Filtration – Membrane Filtration Absorption – Ion Exchange – Advanced oxidation process.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: List the types of constituents present in the wastewater and their health effects.

CO2: Discuss the types of reactors for treating different kinds of wastewater and selection of appropriate types of reactors for the wastewater treatment.

CO3: Illustrate the different kinds of chemical unit processes in wastewater treatment.

CO4: Categorize the different kinds of biological processes in the wastewater treatment.

CO5: Analyze the different types of advanced wastewater treatment technologies.

TEXT BOOKS:

1. Tchobanoglous, G. and Biston, F.I., Wastewater Engineering: Treatment and Reuse, McGraw Hill, 2002.

2. Industrial Waste Water Management Treatment and Disposal by Water Environment Federation McGraw Hill III Edition 2008.

REFERENCES:

1. Arceivala, S.J., and Asolekar, S.R., Wastewater Treatment for Pollution Control and reuse McGraw Hill, Third Edition, New Delhi, 2007.

2. Grady, C.P.L., Daigger, G., and Lim, H.C., Biological Wastewater Treatment, Second Edition, Marcel Dekker, 1999.

3. Karia, G.L., and Christian, R.A., Wastewater Treatment Concepts and Design Approach, PHI, Delhi, Second Edition, 2013.

4. Peavy H.S. Rowe D.R., and George Technologious, Environmental Engineering, McGraw Hill Book Company, Ny, 1985

CO-PO-PSO Mapping

COs	Pos												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2					3	3	1				1		1
2	2					3	3	1				1		1
3	2					3	3	1				1		1
4	2					3	3	1				1		1
5	2					3	3	1				1		1

COURSE CODE	COURSE TITLE	L	T	P	C
UCH2623	ENERGY, ENVIRONMENT AND IMPACT ASSESSMENT	3	0	0	3

COURSE OBJECTIVE:

To enable a comprehensive understanding of the Earth's Energy Budget, the Environment, and the processes leading to Climate Change; The use of Environmental Impact Assessment (EIA) procedures to promote sustainable development

UNIT I EARTH AND ENERGY BALANCE 9

Overview on the Earth's energy requirement vis-à-vis Climate Change. Energy Balance: Earth –Atmosphere System. Solar and Terrestrial Radiation. Absorption of Radiation by gases. Energy balance. Solar variability and the Earth's Energy Balance; Forms and types of Energy;

UNIT II ENVIRONMENTAL VARIABILITY ON ENERGY RESOURCES

USAGE **9**

Environmental Variability: Natural and Anthropogenic. Effects of urbanization, Landscape changes, Influence of Irrigation, Desertification and Deforestation. Carbon footprint of the Built Environment; Environmental Impacts on usage of fossil fuels, nuclear power, solar and wind energy.

UNIT III OVERVIEW OF ENVIRONMENTAL IMPACT ASSESSMENT 9

Environmental Impact Assessment (EIA) and Environmental Impact Statement (EIS) – COURSE OBJECTIVEs – EIA capability and limitations – Legal provisions on EIA. Usage of the mathematical models in EIA – Water quality, air quality and noise; assumptions and limitations. Development of Leopold Matrices and quantifying impacts in the Built Environment.

UNIT IV SAFEGUARDING THE FUTURE 9

The Energy Crisis. The needs of the Developing countries. The role of International Bodies. Kyoto and Montreal Protocol; Paris agreement. Intergovernmental Panel on Climate Change (IPCC 2014).The Stern Report. Carbon Credits. Indian Context Predicting Future Climate Change: Global Climate Models and their role in the EIA process.

UNIT V EIA AND INFRASTRUCTURE DEVELOPMENT PROJECTS AND IMPACTS 9

Case studies – highway, airport, dams, power plans, etc, Plan for mitigation of adverse impact on environment – options for mitigation of impact on water, air and land, flora and fauna; Addressing the issues related to the project affected people, climate impacts and EIA.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Describe the earth energy systems and the potential impacts of human activity on them.

CO2: Discuss the three principal components of the terrestrial ecosystem, namely energy, Environment, and Climate Change.

CO3: Examine the concepts and methodologies of environmental impact assessment.

CO4: Outline the international protocols and agreements on climate change and energy crisis.

CO5: Analyze the various case studies on environmental impact assessment and plan to mitigate the adverse impacts of a project on the environment.

TEXT BOOKS:

1. Peter Hodgson "*Energy, Environment and Climate Change"*. Oxford University Press,2010.
2. Alan Gilpin, "Environmental Impact Assessment: Cutting Edge for the 21st Century" Cambridge University Press, 2012.

REFERENCES:

1. Anjaneyalu Y, "Environmental Impact Assessment Methodologies", B. S. Publications, Hyderabad, 2002.
2. W.R. Cotton and R.A. Pielke, "Human Impacts on Weather and Climate", Cambridge University Press, 2007.

CO-PO-PSO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2

1	2					3	3	1				1		1
2	2					3	3	1				1		1
3	2					3	3	1				1		1
4	2					3	3	1				1		1
5	2					3	3	1				1		1

COURSE CODE	COURSE TITLE	L	T	P	C
UCH2624	**SYNTHESIS AND APPLICATIONS OF NANOMATERIALS**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

- To explore the basic concepts and ideas involved in the synthesis of nanomaterials and to implement different strategies for synthesizing 0, 1D, 2D nanomaterials.
- To explore the role and application of nanomaterials in various fields.

UNIT I MECHANICAL ALLOYING & MILLING 9

Introduction to synthesis of nanostructure materials, bottom-up approach and top-down approach–equipment for mechanical alloying, process variables in milling, Mechanism of alloying, Mechanochemical Processing-Thermodynamic Aspects, Powder Contamination, Safety Hazards Related to Mechanical Alloying Processes

UNIT II CHEMICAL ROUTES FOR SYNTHESIS OF NANOMATERIALS 9

Chemical precipitation and co-precipitation; Metal nanocrystals by reduction, Sol-gel synthesis; Microemulsions or reverse micelles, myle formation; Solvothermal synthesis; Thermolysis routes, Microwave heating synthesis; Sonochemical synthesis; Electrochemical synthesis; Photochemical synthesis, Synthesis in supercritical fluids

UNIT III FABRICATION OF NANOMATERIALS BY PHYSICAL METHODS 9

Inert gas condensation, Arc discharge, Plasma arc technique, RF plasma, MW plasma, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy, Chemical vapour deposition method and Electro deposition

UNIT IV NANOPOROUS MATERIALS 9

Zeolites and Mesoporous Materials-Synthesis, properties and applications, Role of nanomaterial sand nanomembranes in water purification-Carbon nanotubes and graphene-Core shell nanostructures and hybrid nanocomposites.

UNIT V APPLICATION OF NANOMATERIAL 9

Nanotechnology for waste reduction and improved energy efficiency, coating, membrane-based application, nanoelectronics, Nanoporous polymers and their applications in water purification, Use of nanoparticles for environmental remediation and water treatment**.**

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Summarize about the synthesis of nanomaterials.

CO2: Examine the different chemical routes for the preparation of nanomaterials.

CO3: Examine the physical approach of nano material synthesis.

CO4: Analyze various nanoporous materials in water purification.

CO5: Apply various nanomaterials in the field of energy, materials and environmental remediation.

TEXT BOOKS:

1. A S Edelstien, RC Cammarata, Nanomaterials: Synthesis, Properties and Application; Taylor & Francis. 1996.
2. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties &Applications, Imperial College Press, 2004.

REFERENCES:

1. J.George, Preparation of Thin Films, Marcel Dekker, Inc., New York. 2005.
2. K. Barriham, D.D. Vvedensky, Low dimensional semiconductor structures: fundamental and device applications, Cambridge University Press, 2001.
3. S.P. Gaponenko, Optical Properties of semiconductor nanocrystals, Cambridge University Press, 1980.
4. W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate(Eds.), Handbook of NanoScience, Engg. and Technology, CRC Press, 2002.

CO-PO-PSO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1						1				2				2
2										3				
3										3				
4						2	3			3				2
5	3					2	3			2				3

COURSE CODE	COURSE TITLE	L	T	P	C
UCH2626	CARBON CAPTURE UTILIZATION AND STORAGE	3	0	0	3

COURSE OBJECTIVE:

To impact knowledge in the field of carbon capture, utilization and storage technologies.

UNIT I INTRODUCTION TO CARBON CAPTURE 9

What is CCS; Physical and Chemical Properties of Fluids - Pure CO_2 and Mixtures; Sources of Emission; Indian & Global Scenario in CO_2 Emission; Challenges; Need for CCS; Methods For CCS - Pre-combustion, Post-combustion and Oxy-fuel Combustion.

UNIT II SOLVENT AND SORBENTS BASED CCS 9

Carbonate-based CO_2 Absorption; Amine-based CCS Technology; Ammonia-based CO_2 Capture and Amine Blends; Carbon-based Sorbents; Polymer Supported Capture Agents; Pressure Swing Adsorption Technologies.

UNIT III BIOLOGICAL METHOD OF CCS 9

Oceanic Fertilization; Terrestrial Sequestration - Soil-carbon Sequestration - Phyto-Sequestration.

UNIT IV CO_2 CONVERSION 9

CO_2 Conversion - Photo Catalytic Conversion and Electro Catalytic Conversion - Biological Conversion.

UNIT V CO_2 UTILIZATION AND STORAGE 9

Utilization -Extractant - Mineralization - Chemicals - Refrigerants - Inerting Agents - Fire Suppression - Plastics - Enhanced Fuel Recovery - Food/Products. Geologic Storage - Depleted Oil And Gas Fields - Deep Saline Formations - Un-mineable Coal Seams - Basalt Formations. Health, Safety and Environmental Issues Associated with CO_2 Storage.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Describe the importance and challenges in the CO_2 capture process.

CO2: Articulate the novel solvents and sorbents for CO_2 capture process.

CO3: Categorize the biological methods of CO_2 capture process.

CO4: Devise the suitable CO_2 conversion techniques.

CO5: Identify the effective ways for CO_2 utilization and storage.

TEXT BOOKS:

1. Stephen A. R., Carbon Capture and Storage, Elsevier, 2nd Edition, 2017.
2. Wilhelm K., Jürgen F. H., Carbon Capture, Storage and Use, Springer, 2015.

REFERENCES:

1. Martin M. H., and Meyer S., Greenhouse Gas Carbon Dioxide Mitigation: Science and Technology, CRC Press,1st Edition, 1998.
2. Fan S and Bryan M., Novel Materials for Carbon Dioxide Mitigation Technology, Elsevier, 1st Edition, 2015.
3. Wilcox and Jennifer., Carbon Capture, ISBN 978-1-4614-2215-0, Springer, 1st Edition, 2012.
4. Howard J. Herzog., Carbon Capture, ISBN: 9780262535755, The MIT Press, 2018.

CO-PO-PSO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1						1	3			2		2		2
2	3				2		3						2	
3	3					3	3						2	
4	3						3							2
5						1	3							2

COURSE CODE	COURSE TITLE	L	T	P	C
UCH2627	DRUGS AND PHARMACEUTICAL TECHNOLOGY	3	0	0	3

COURSE OBJECTIVE:

To give the students an understanding of the polytechnical nature of engineering and drug discovery in the pharmaceutical industry involving Chemical Engineering.

UNIT I INTRODUCTION 9

Development of drugs and pharmaceutical industry; organic therapeutic agents uses and economics

UNIT II DRUG METABOLISM AND PHARMACO KINETICS 9

Mechanism of drug action; physico-chemical principles of drug metabolism; Pharmacokinetics, Pharmacodynamics, Factors modifying drug action, adverse drug reaction, drug interactions, Bioassay of drugs

UNIT III DRUG MANUFACTURING PROCESS AND THEIR APPLICATIONS 9

Types of chemical conversion processes; alkylation; carboxylation; condensation and cyclisation; dehydration, esterification, halogenation, oxidation, sulfonation; complex chemical conversions-fermentation & commercial drug manufacture process

UNIT IV PRINCIPLES OF DRUG MANUFACTURE 9

Compressed tablets; wet granulation; dry granulation or slugging; advancement in granulation; direct compression, tablet presses formulation; coating pills; capsules sustained action dosage forms; parental solutions, oral liquids; injections; ointments

UNIT V PHARMACEUTICAL ANALYSIS & QUALITY CONTROL 9

Analytical methods and tests for various drugs and pharmaceuticals – spectroscopy, chromatography, fluorimetry, polarimetry, refractometry, pH metry, packing techniques; quality control.

Total: 45 Periods

COURSE OUTCOMES:

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

CO1: Articulate on development of drugs, organic therapeutic agents and their economics.

CO2: Apply the chemical principles of drug metabolism, pharmaco-kinetics and pharmaco-dynamics.

CO3: Categorize the chemical conversion process of manufacturing drugs and their applications.

CO4: Summarize the unit processes involved in manufacturing of drugs.

CO5: Apply suitable analytical methods for testing and quality control of various drugs.

TEXT BOOKS:

1. Rawlines, E.A.; "Bentleys Text book of Pharmaceutics ", III Edition, Bailliere Tindall, London, 1977.

2. Yalkonsky, S.H.; Swarbick. J.; "Drug and Pharmaceutical Sciences ", Vol. I, II, III, IV, V, VI and VII, Marcel Dekkar Inc., New York, 1975.

REFERENCES:

1. Remingtons Pharmaceutical Sciences ", Mack Publishing Co., 1975.

2. Schoenwald, R.D., "Pharmacokinetics in Drug Discovery and Development", CRC 2002

3. Ansel, H.C. "Pharmaceutical Dosage Forms and Drug Delivery Systems", 7th Edition, Lippincott Williams & Wilkins, 2000.

CO-PO-PSO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2			1			1					1		1
2	2			1			1							1

3	2			1			1							1
4	2			1			1							1
5	2			1	1		1					1		1

COURSE CODE	COURSE TITLE	L	T	P	C
UCH2628	**SOLID WASTE MANAGEMENT**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

- To provide comprehensive overview of solid and hazardous waste management.
- To provide knowledge on solid waste management design aspects

UNIT - I MUNICIPAL SOLID WASTE 7

Definition - Sources and types of solid waste- composition and its determinants of Solid waste-factors influencing generation-quantity assessment of solid wastes-methods of sampling and characterization.

UNIT - II COLLECTION AND TRANSFER 9

Collection: Collection of Solid waste – collection services – collection system, equipments – time and frequency of collection – labour requirement – factors affecting collection – analysis of collection system – collection routes – preparation of master schedules.

Transfer and Transport: Need for transfer operation – transfer stations – types – transport means and methods – location of transport stations - Manpower requirement – collection routes: Transfer stations – selection of location, types & design requirements, operation & maintenance**.**

Unit - III PROCESSING TECHNIQUES AND RECOVERY OF ENERGY 10

Processing techniques – purposes mechanical volume reduction – necessary equipments – chemical volume reduction – incinerators – mechanical size reduction selection of equipments – components separation – methods – drying and dewatering.

Recovery of Resources, conversion products and energy recovery – recoverable materials – processing and recovery systems – incineration with heat recovery.

Unit - IV DISPOSAL OF SOLID WASTES 10

Refuse disposal – various methods – incinerations – principle features of an incinerator – site selection and plant layout of an incinerator - sanitary landfill- methods of operation – advantages and disadvantages of sanitary land fill - site selection – reactions accruing in completed landfills – gas and leachate movement and control – equipments necessary.

Unit - V HAZARDOUS WASTE MANAGEMENT 9

Need for hazardous waste management – Sources of hazardous wastes – Effects on community – terminology and classification – Storage and collection of hazardous wastes – Problems in developing countries – Protection of public health and the environment.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the importance of municipal solid waste management and utilize the characteristics of solid waste to make a suitable decision on waste management options.

CO2: Explain a plan for effective collection and transfer of solid waste.

CO3: Demonstrate different methods of solid waste processing and perform preliminary calculations for energy recovery systems.
CO4: Select the suitable principles and method for effective operation of solid waste disposable techniques.
CO5: Classify hazardous wastes and explain the techniques suitable for hazardous waste handling.

TEXTBOOKS:

1. George Techobanoglous et al,"Integrated Solid Waste Management" McGraw - Hill, 1993.
2. Techobanoglous Thiesen Ellasen; Solid Waste Engineering Principles and Management, McGraw - Hill 1997.

REFERENCES:

1. CPHEEO, Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organization, Government of India, New Delhi, 2000.
2. LaGrega, M.D., Buckingham, P.L., Jeffrey, C. E., Environmental Resources Management, Hazardous waste Management, McGraw Hill International edition, New York, 2001.
3. Vesilind, P.A., Worrell, W and Reinhart, Solid waste Engineering, Thomson Learning Inc.,Singapore, 2002.
4. Wentz, C.A., Hazardous Waste Management, McGraw-Hill Publication, 1995.

CO-PO-PSO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2		1			3	3	1				1		1
2	2		1			3	3	1				1		1
3	2		1			3	3	1				1		1
4	2		1			3	3	1				1		1
5	2		1			3	3	1				1		1

COURSE CODE	COURSE TITLE	L	T	P	C
UCH2630	BIO-ENERGY TECHNOLOGY	3	0	0	3

COURSE OBJECTIVE:

- To learn the different kinds of feed stocks for energy generation.
- To learn the different kinds of energy conservation techniques.
- To design the different types of systems for the utilization of bio-energy.

UNIT I INTRODUCTION TO BIO-ENERGY 8

Biomass – types – advantages and drawbacks, Bio-energy overview, Biomass composition - Ultimate and proximate analyses-Heating value – Biomass resources - Modes of biomass utilization for Energy - Biomass conversion processes - Characteristics of biomass fuels.

UNIT II BIOMETHANATION 9

Biogas production - Types of substrates – Process parameters - Digester design - Operational problems – Biogas kinetics – Gas cleaning – Thermal and electrical conversion – High rate anaerobic digestion systems – Sludge utilization. Chemical kinetics and mathematical modeling of bio-methanation process; Economics of biogas plant with their Environmental and social impacts.

UNIT III ETHANOL AND METHANOL PRODUCTION 10

Ethanol and Methanol production using chemical and biological processes: Bioconversion of substrates into alcohol: Methanol & ethanol production, organic acids, solvents, amino acids, etc. Chemical Conversion: Hydrolysis and hydrogenation; Solvent extraction of hydrocarbons; Solvolysis of wood; Bio-crude and biodiesel, Distillation– Biodiesel: Preparation, characteristics and applications, Chemicals from biomass.

UNIT IV BIOMASS COMBUSTION 9

Biomass combustion reactions – Combustion systems – Wood stoves and industrial combustion systems – Fluidized bed combustion systems – Phase theory - Densification – Types of devices – Performance parameters – Feed preparation – Properties of densified fuels –Applications - Charcoal production – Dendrothermal power generation.

UNIT V PYROLYSIS 9

Pyrolysis - Slow and fast pyrolysis – Biomass gasification –Types of gasifiers - Fluidized bed gasification - Equilibrium and kinetic considerations – Gas cleaning – Thermal applications –Energy from industrial wastes, Decentralised power generation.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Explain the types of biomass availability for energy generation and analyze the biomass characterization data.

CO2: Outline the design specifications and operational problems in bio-methanation production and apply the concepts of chemical kinetics.

CO3: Explain the chemical and biological processes involved in the production of ethanol and methanol from biomass.

CO4: Discuss the biomass combustion systems for domestic and industrial usage.

CO5: Describe the application of pyrolysis and gasification in bio-energy production from biomass.

TEXT BOOKS:

1. Lijun Wang, Sustainable bio-energy Production, 2014, CRC Press.
2. Sunggyu Lee, Y.T. Shah, Bio fuels and bio energy ; processes and technologies, 2012, CRC Press.

REFERENCES:

1. Anju Dahiya, Bio energy; bio mass to bio fuels, 2014, Academic press.
2. Hang Bailiang, Bio energy technology and Engineering 2013, Alpha Science Int. ltd.
3. Gerhard Knothe, Jon Van Gerpen and Jurgen Krahl (2005), The Biodiesel Handbook, ISBN: 1893997790.
4. Iyer PVR et al, Thermochemical Characterization of Biomass, M N E S
5. Khandelwal KC, Mahdi SS, Biogas Technology – A Practical Handbook, Tata McGraw Hill, 1986

CO-PO-PSO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2									2		2		1
2	2									2		2		1
3	2									2		2		1
4	2									2		2		1
5	2									2		2		1

COURSE CODE	COURSE TITLE	L	T	P	C

UCH2721	GREEN CHEMISTRY AND ENGINEERING	3	0	0	3

COURSE OBJECTIVE:

To make the students aware of global environmental issues, concepts behind pollution prevention, environmental risks, green chemistry, methods to evaluate environmental costs and life cycle assessments

UNIT I OVERVIEW OF ENVIRONMENTAL ISSUES 9

Global Environmental Issues. Air Quality Issues. Water Quality Issues, Ecology, Natural Resources, Description of Risk. Value of Risk Assessment in the Engineering Profession. Risk-Based Environmental Law. Risk Assessment Concepts. Hazard Assessment. Dose- Response. Risk Characterization.

UNIT II POLLUTION PREVENTION 9

Pollution Prevention Concepts and Terminology. Chemical Process Safety. Responsibilities for Environmental Protection. Environmental Persistence. Classifying Environmental Risks Based on Chemical Structure. Exposure Assessment for Chemicals in the Ambient Environment.

UNIT III GREEN CHEMISTRY 9

Green Chemistry Methodologies. Quantitative/Optimization-Based Frameworks for the Design of Green Chemical Synthesis Pathways. Green Chemistry Pollution Prevention in Material Selection for Unit Operations. Pollution Prevention for Chemical Reactors. Pollution Prevention for Separation Devices. Pollution Prevention Applications for Separative Reactors. Pollution Prevention in Storage Tanks and Fugitive Sources.

UNIT IV PROCESS INTEGRATION 9

Process Energy Integration. Process Mass Integration. Case Study of a Process Flow sheet- Estimation of Environmental Fates of Emissions and Wastes

UNIT V LIFE CYCLE ASSESSMENT 9

Magnitudes of Environmental Costs. A Framework for Evaluating Environmental Costs. Hidden Environmental Costs. Liability Costs. Internal Intangible Costs. External Intangible Costs. Introduction to Product Life Cycle Concepts. Life-Cycle Assessment. Life-Cycle Impact Assessments. Streamlined Life-Cycle Assessments. Uses of Life-Cycle Studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Describe global environmental issues and apply the risk assessment techniques in the engineering profession.

CO2: Explain pollution prevention methods and assess the impact of chemical structure of pollutant on the ambient atmosphere.

CO3: Apply green chemistry pathways and the pollution prevention steps while handling chemical reactors, separator devices and storage tanks manufacturing.

CO4: Analyze process energy integration and mass integration using a case study relevant to chemical engineering.

CO5: Select a life cycle assessment framework for various energy and product technologies in the chemical industry.

TEXT BOOKS:

1. Allen, D.T., Shonnard, D.R, Green Engineering: Environmentally Conscious Design of Chemical

Processes. Prentice Hall PTR 2002.

2. Mukesh Doble and Anil Kumar Kruthiventi, Green Chemistry and Engineering, Elsevier, Burlington, USA, 2007.

REFERENCES:

1. Anastas, P.; Warner, J. Green Chemistry: Theory and Practice; Oxford University Press: London, 1998

2. Zimmerman, J.B.; Anastas, P.T. "The 12 Principles of Green Engineering as a Foundation for Sustainability" in Sustainability Science and Engineering: Principles.Ed. Martin Abraham, Elsevier Science. available 2005.

3. Anastas, P.; Zimmerman, J. "Design through the Twelve Principles of Green Engineering," Environmental Science and Technology, 37, 94A – 101A, 2003.

4. Tundro, P.; Anastas, P., Green Chemistry Challenging Perspectives, Oxford Press, Oxford, 2000.

5. Matlack, A.S., Introduction to Green Chemistry, Marcel Dekker, Inc., New York, 2001.

CO-PO-PSO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	2					3	3	1				1		2
2	2					3	3	1				1		2
3	2					3	3	1				1		2
4	2					3	3	1				1		2
5	2					3	3	1				1		2

COURSE CODE	COURSE TITLE	L	T	P	C
UCH2723	**FUEL CELLS**	**3**	**0**	**0**	**3**

COURSE OBJECTIVE:

To give the students an understanding of different types of fuel cells and their applications in involved in power sector.

UNIT I FUEL CELLS 9

History – principle – working – thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery vs fuel cell

UNIT II TYPES OF FUEL CELLS 9

Types of fuel cells – Alkaline Fuel Cell (AFC), Phosphoric Acid Fuel Cell (PAFC), Solid Oxide Fuel Cell (SOFC), Molten Carbonate Fuel Cell (MCFC), Direct Methanol Fuel Cell (DMFC), Proton Exchange Membrane Fuel Cell (PEMFC) – fuel cell operation - relative merits and demerits

UNIT III FUEL CELL THERMODYNAMICS 9

Fuel cell thermodynamics - heat, work potentials, prediction of reversible voltage, fuel cell efficiency.

UNIT IV FUEL CELL REACTION KINETICS 9

Fuel cell reaction kinetics - electrode kinetics, overvoltages, Tafel equation, charge transfer reaction, exchange currents

UNIT V APPLICATION OF FUEL CELLS AND ECONOMICS 9

Fuel cell usage for domestic power systems, large scale power generation, Automobile. Economic,

environmental and life cycle analysis on usage of Fuel cell

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Describe the working principles and performance of fuel cells. (k1)

CO2: Classify the various types of fuel cells with their merits and demerits (k2)

CO3: Predict the fuel cell efficiency based on thermodynamic principles (k3)

CO4: Interpret the reaction kinetics of fuel cell operation (k2)

CO5: Apply the fuel cell concepts in domestic, automobile and industrial sectors (k3)

TEXT BOOKS:

1. Viswanathan, B M AuliceScibioh, Fuel Cells-Principles and Applications,University Press (2006)
2. Kordesch, K and G. Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany (1996).

REFERENCES:

1. O'Hayre, R.P.,S. Cha, W. Colella, F.B.Prinz, Fuel Cell Fundamentals, Wiley, NY (2006).
2. Bard, A. J. , L. R., Faulkner, Electrochemical Methods, Wiley, N.Y.(2004)
3. Liu, H., Principles of fuel cells, Taylor & Francis, N.Y. (2006)

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CO-PO-PSO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	2	1			2		3		3	3			1	
2	2	3	3	3	3				3	3			1	
3	3	3	3	3	3				3	3			1	
4	2	3	3	3	3				3	2			1	
5	3	3	3	3	3				3	3			1	

COURSE CODE	COURSE TITLE	L	T	P	C
UCH2729	**ALTERNATIVE FUELS**	**3**	**0**	**0**	**3**

COURSE OBJECTIVE:

The course is aimed to understand the application of alternate fuels and their limitations for a sustainable environment.

UNIT I NEED FOR ALTERNATIVE FUELS 9

Exhaust gas emission in atmosphere and its effects. Factors affecting greenhouse effect. Global Carbon Budget, Carbon foot print and Carbon credit calculations. Emission norms as per Bharat Standards

UNIT II ALCOHOLS, BIODIESEL & VEGETABLE OILS 9

Properties as engine fuel, alcohols and gasoline blends, performance in engine. Production and separation of Biodiesel. Properties Diesel blended with vegetable oil, difference in performance of Engine.

UNIT III HYDROGEN, BIOGAS, LPG & CNG 9

Hydrogen: Properties, Sources and methods of production. Biogas: Factors affecting biogas formation, Usage of Biogas in engines. LPG & CNG: Properties of LPG & CNG as engine fuels, Effect on performance, emission, cost and safety.

UNIT IV ELECTRIC, HYBRID, FUEL CELL AND SOLAR CARS 12

Electric vehicle: advantage and limitations, specifications, system components, electronic control system, high energy and power density batteries, hybrid vehicle, fuel cell vehicles, solar powered vehicles.

UNIT V OTHER SYNTHETIC FUELS 6

Dimethyl ether (DME), P-Series fuels, Eco Friendly Plastic fuels (EPF).

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the need for alternative fuels.

CO2: Summarize the performance of the engine on application of alcohols, biodiesel and vegetable oils as fuels.

CO3: Predict the engine performance, emission cost and safety on using hydrogen, biogas, LPG & CNG as alternative fuels.

CO4: Analyze the advantages and limitations of electric, hybrid, fuel cell and solar cars.

CO5: Categorize various synthetic fuels and their applications.

TEXT BOOKS:

1. S. S. Thipse, Alternative Fuels, 1st edn, Jaico Publications, 2010
2. Sunggyu Lee, James G. Speight, Sudarshan K. Loyalka, Handbook of Alternative Fuel Technologies, 2nd edn., CRC Press, 2018.

REFERENCES BOOKS:

1. Maximino Manzanera, Alternative Fuel, Intechopen Publications, 2011
2. A.S. Ramadhas, Alternative Fuels for Transportation, CRC Press, 2010
3. Singh, A.P., Agarwal, R.A., Agarwal, A.K., Dhar, A., Shukla, Prospects of Alternative Transportation Fuels, Springer Singapore, 2018
4. K.Venkateswarlu and B.S.R. Murthy, Alternative fuels and advanced vehicle technologies, PHI, 2021

CO-PO-PSO Mapping

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	2					3	3	1				1		2
2	2					3	3	1				1		2
3	2					3	3	1				1		2
4	2					3	3	1				1		2
5	2					3	3	1				1		2

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
UCH2823	**FRONTIERS OF CHEMICAL ENGINEERING**	**3**	**0**	**0**	**3**

COURSE OBJECTIVE:

The course is aimed to know the latest trends to be followed in the process industries

UNIT I PROCESS INTENSIFICATION 9

Novel reactor configurations; combination of reaction and separation; use of different energy fields,. Role of Process intensification in sustainable development

UNIT II CHEMICAL PRODUCT DESIGN 9

Scope and importance; identification of needs and specifications; sources of ideas and screening ideas; selection of product; process development for product manufacture; economic aspects.

UNIT III RENEWABLE ENERGY 9

Hydrogen production, Hydrogen economy, Fuel Cell Technology, biofuel cells and bio-hydrogen, recent advancements in wind and solar energy

UNIT IV MATERIALS ENGINEERING 9

Polymers and composites, ceramics and glasses, colloidal dispersions and nanoparticles, thin films and electronic materials, Optical fiber, carbon nanotube

UNIT V BIOENGINEERING 9

Biomechanics, biotransport and biomaterials, bioartificial organs, drug discovery and development.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Describe the role of process intensification for sustainable development.

CO2: Summarize the concepts of chemical product design.

CO3: Explain the benefits of various types of renewable energy resources.

CO4: Discuss on the improved properties of various engineered materials.

CO5: Summarize the bioengineering principles and their advanced applications.

TEXT BOOKS:

1. Keil, F. J., Modeling of Process Intensification Wiley-VCH Verlag GmbH & Co., 2007
2. Cussler, E.l. and Moggridge, G.D., "Chemical product design" Cambridge University Press, Cambridge, 2001
3. Hoffmann,P, Tomorrow's energy: hydrogen, fuel cells, and the prospects for a cleaner planet, MIT Press, Sabon, 2002.

REFERENCES:

1. Mitchell, B.S., An introduction to materials engineering and science for chemical and materials engineers, John Wiley and Sons Inc., New Jersey, 2004
2. Richard Turton, Joseph Shaeiwitz, Debangsu Bhattacharyya, Wallace Whiting, Analysis, Synthesis and Design of Chemical Processes, 5th Edition, Pearson, 2018
3. Laurent Simon, Control of biological and drug delivery system for Chemical, biomedical and pharmaceutical, Engineering, Wiley, 2013
4. C. Ross Ethier, Craig A. Simmons, Introductory Biomechanics: From Cells to Organisms, Cambridge University Press, 2007.

CO-PO-PSO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	2	2			1						1		2
2	3	2	2			2						1		2
3	2	2	3			2						1		2
4	2					2						1		2
5	2					2						1		2

COURSE CODE	COURSE TITLE	L	T	P	C
UCH2824	PETROLEUM REFINING AND PETROCHEMICALS	3	0	0	3

COURSE OBJECTIVE:

- Students will gain knowledge about petroleum refining process and production of various petrochemical products

UNIT I INTRODUCTION 9

Origin, Formation and Evaluation of Crude Oil. Testing of Petroleum Products. Refining of Petroleum – Atmospheric and Vacuum Distillation.

UNIT II CRACKING AND REFORMING 9

Cracking, Thermal Cracking, Vis-breaking, Coking, Catalytic Cracking (FCC), Cracking of Naphtha, Hydro Cracking, Reforming - Reaction and feed preparation for reforming process, Catalytic reforming process.

UNIT III ISOMERIZATION, ALKYLATION AND POLYMERIZATION 9

Isomerization – Reaction, Process variables, Isomerization process, Alkylation – Reaction, Process variable and feed stock, Hydrofluoric acid and Sulfuric acid alkylation process, Polymerization – Reaction and process variable, Polymerization process.

UNIT IV TREATMENT TECHNIQUES 9

Treatment Techniques: Removal of Sulphur Compounds in all Petroleum Fractions to improve performance, Lube oil processing, Solvent Treatment Processes, Dewaxing, Clay Treatment and Hydrofining.

UNIT V PRODUCTION OF PETROCHEMICALS 9

Production of Petrochemicals like Dimethyl Terephthalate (DMT), Ethylene Glycol, Synthetic Glycerin, Linear Alkyl Benzene (LAB), Acrylonitrile, Methyl Methacrylate (MMA), Vinyl Acetate Monomer, Phthalic Anhydride, Maleic Anhydride, Phenol and Acetone, Methanol, Formaldehyde, Acetaldehyde.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1: Summarize on the classification, composition and testing methods of crude oil/products for developing the refining process.

CO2: Describe cracking and reforming processes for enhancing the quality of petroleum products.

CO3: Articulate on various processes for Isomerization, Alkylation and Polymerization of petroleum products.

CO4: Apply the various treatment processes for improving the quality of petroleum products.

CO5: Explain the different processes involved in the production of petrochemical products.

TEXT BOOKS:

1. Nelson, W. L., “Petroleum Refinery Engineering”, 4th Edn., McGraw Hill, New York, 1985.
2. Bhaskara Rao, B. K., “Modern Petroleum Refining Processes”, 2nd Edn., Oxford and IBH

Publishing Company, New Delhi, 1990.

REFERENCES:

1. Wiseman. P., Petrochemicals, UMIST Series in Science and Technology.
2. H. Steiner, Introduction to petrochemicals Industry, Pergamon, 1961.
3. Bhaskara Rao, B. K. "A Text on Petrochemicals", 1st Edn., Khanna Publishers, New Delhi, 1987.
4. James H. Gary, Glenn E. Handwerk and Mark J. Kaiser, "Petroleum Refining Technology and Economics", 5thEdn., CRC Press, New York, 2007.

CO-PO-PSO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1									2	2				
2	2								2	2			2	
3	3								3	3			2	
4	3								3	3			2	
5	3								3	3			2	

COURSE CODE	COURSE TITLE	L	T	P	C
UCH2826	ENERGY TECHNOLOGY	3	0	0	3

COURSE OBJECTIVE:

To understand various energy conversion technologies for generating thermal / electrical energy, and analyse the energy conservation ideas.

UNIT I ENERGY SCENARIO 9

Units of energy and power, Classification of energy sources.Availability of fossil fuels and in various parts of the world. Electrical energy – installed capacities, contribution by various energy forms – Indian and Global scenario. Per capita energy usage - variation among the nations. Impact of energy production on environment.

UNIT II CONVENTIONAL TECHNOLOGIES 9

Components and thermodynamics of thermal power plant, Coal and gas based power plants.
Nuclear power plant – types. Hydropower plant. Pumped hydro for energy management. Developments in thermal, nuclear, and hydro power installations.

UNIT III RENEWABLE ENERGY TECHNOLOGIES 9

Solar irradiation, Solar power plant – solar thermal, solar photo-voltaic, solar dryers, solar water heaters, solar chimney. Wind power – variables affecting power potential, Wind turbine types. Geothermal energy, Energy from ocean – tidal, wave, ocean-thermal. Developments in solar, wind, geothermal and ocean energy installations.

UNIT IV ENERGY FROM BIOMASS 9

Biomass – types, availability. Biomethanation – variables affecting the reaction, reactor types. Combustion – fluidized bed combustor – co-firing with coal. Gasification – types. Pyrolysis, carbonization – equipments, yield Biofuels – bioethanol, biodiesel – preparation methods. Energy from municipal waste. Developments in biomass energy utilization.

UNIT V ENERGY CONSERVATION AND AUDITING 9

Energy conservation opportunities in chemical process utilities – pumps, compressors, refrigeration systems, cooling towers. Energy Conservation Act – Role of Bureau of Energy Efficiency India, Implementation strategies - Energy auditing.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Categorize energy sources and assess the energy demand and impact of energy production on the environment.
CO2: Articulate energy management through technology developments in conventional power plants.
CO3: Summarize the developments in renewable energy technologies.
CO4: Summarize the developments in biomass energy conversion and its utilization.
CO5: Articulate on energy conservation, implementation strategies and auditing.

TEXT BOOKS:

1. John Andrews and Nick Jelley, Energy Science, Oxford University Press, 3rd edition, 2017
2. Clive Beggs, Energy: Management, Supply and Conservation, Elsevier Science & Technology Books, 2002.

REFERENCES:

1. World Energy Outlook Reports by International Energy Agency (IEA)
2. Aldo Vieira da Rosa, Fundamentals of Renewable Energy Processes, Elsevier Academic Press, 2005.
3. Roy L. Nersesian, Energy for the 21st Century, M.E. Sharpe, Inc., New York, 2007.
4. Energy Manager Training Exam Guide Books by Bureau of Energy Efficiency, India.

CO-PO-PSO Mapping

COs	**Pos**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	2	3	3						2				1	
2	2	3	3	3	2				2				1	
3	3	3	3						2				1	
4	1	2	3		1				1				1	
5	2	3	3	3					1				1	

MBA

PBA2224 SUSTAINABLE DEVELOPMENT 3 0 0 3

LEARNING OUTCOMES:

CO 1: Develop an understanding of sustainability management as an approach to aid in evaluating and minimizing environmental impacts while achieving the expected social impact.

CO 2: Demonstrate an understanding of corporate sustainability and responsible Business Practices.

CO 3: Understand, measure and interpret sustainability performances.

CO 4: Demonstrate knowledge of innovative practices in sustainable business and community management

CO 5: Deep understanding of sustainable management of resources and commodities

UNIT I MANAGEMENT OF SUSTAINABILITY 8

Management of sustainability -rationale and political trends: An introduction to sustainability management, International and European policies on sustainable development, theoretical pillars in sustainability management studies.

UNIT II CORPORATE SUSTAINABILITY AND RESPONSIBILITY 8

Corporate sustainability perimeter, corporate sustainability institutional framework, integration of sustainability into strategic planning and regular business practices, fundamentals of stakeholder engagement.

UNIT III SUSTAINABILITY MANAGEMENT: STRATEGIES & APPROACHES 9

Corporate sustainability management and competitiveness: Sustainability-oriented corporate strategies, markets and competitiveness, Green Management between theory and practice, Sustainable Consumption and Green Marketing strategies, Environmental regulation and strategic postures; Green Management approaches and tools; Green engineering: clean technologies and innovation processes; Sustainable Supply Chain Management and Procurement.

UNIT IV SUSTAINABILITY AND INNOVATION 8

Socio-technical transitions and sustainability, Sustainable entrepreneurship, Sustainable pioneers in green market niches, Smart communities and smart specializations.

UNIT V SUSTAINABLE MANAGEMENT OF RESOURCES, COMMODITIES AND COMMONS 9

Energy management, Water management, Waste management.

TOTAL SESSIONS 42

TEXTBOOK:

1. Petra Molthan-Hill, The Business Student's Guide to Sustainable Management: Principles and Practice, Greenleaf Publishers, 2014

REFERENCE BOOKS:
1. Tiberio Daddi, Fabio Iraldo, Francesco Testa, Environmental Certification for Organizations and Products: Management, Routledge Publishers, 2016
2. Christian N. Madu, Handbook of Sustainability Management World Scientific 2012
3. Margaret Robertson, Sustainability Principles and Practice, Cambridge University Press 2014
4. Peter Rogers, An Introduction to Sustainable Development, Glen Education Foundation, Inc, 2006.

PBA2221 ENTREPRENEURSHIP DEVELOPMENT 3 0 0 3

LEARNING OUTCOMES

CO 1 Gain an understanding of entrepreneurial competence to run a business efficiently.

CO 2 Prepare business plans and understand feasibility.

CO 3 Prepare plan for launching a business taking into account the various policies' support.

CO 4 Appreciate the factors leading to success and failure from entrepreneurs.

UNIT I ENTREPRENEURAL COMPETENCE 8

Entrepreneurship concept – Entrepreneurship as a Career – Entrepreneurial Personality - Characteristics of Successful Entrepreneurs – Knowledge and Skills of an Entrepreneur.

UNIT II ENTREPRENEURAL ENVIRONMENT 8

Business Environment - Role of Family and Society - Entrepreneurship Development Training and Other Support Organisational Services - Central and State Government Industrial Policies

and Regulations.

UNIT III BUSINESS PLAN PREPARATION 9

Sources of Product for Business - Prefeasibility Study - Criteria for Selection of Product - Ownership - Capital Budgeting- Project Profile Preparation - Matching Entrepreneur with the Project - Feasibility Report Preparation and Evaluation Criteria.

UNIT IV LAUNCHING OF SMALL BUSINESS 8

Finance and Human Resource Mobilisation - Operations Planning - Market and Channel Selection - Growth Strategies - Product Launching – Incubation, Venture capital, Start-ups.

UNIT V MANAGEMENT OF SMALL BUSINESS 9

Monitoring and Evaluation of Business - Business Sickness - Prevention and Rehabilitation of Business Units - Effective Management of small Business - Case Studies.

TOTAL SESSIONS: 42

TEXTBOOK:
1. S.S.Khanka, Entrepreneurial Development, S.Chand and Company Limited, New Delhi, 2016.
REFERENCE BOOKS:
1. R.D.Hisrich, Entrepreneurship, Tata McGraw Hill, New Delhi, 2018.
2. Rajeev Roy, Entrepreneurship, Oxford University Press, 2nd Edition, 2011.
3. Donald F Kuratko,T.V Rao. Entrepreneurship: A South Asian perspective. Cengage Learning, 2012.
4. Dr. Vasant Desai, "Small Scale Industries and Entrepreneurship", HPH, 2006.
5. Arya Kumar. Entrepreneurship, Pearson, 2012.
6. Prasanna Chandra, Projects – Planning, Analysis, Selection, Implementation and Reviews, Tata McGraw-Hill, 8th edition, 2017.

SDGs mapping of courses – B.E. Mechanical

COURSE NAME		SUSTAINABLE DEVELOPMENT GOALS																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
43	Renewable sources of Energy							✓	✓	✓								✓
70	Sustainable Manufacturing System	✓	✓	✓					✓	✓			✓					✓
75	Alternative Fuels & Emission Control for Automobile							✓	✓	✓		✓		✓				
83	Electric Vehicles							✓	✓	✓		✓		✓				✓
84	Energy Efficient Buildings							✓	✓	✓		✓	✓					
92	Principles of Energy Conservation, Audit and Management							✓	✓	✓			✓					
100	Solar Energy Technology							✓	✓	✓		✓						✓

Course Code	Course Title	L	T	P	C
UME2622	RENEWABLE SOURCE OF ENERGY	3	0	0	3

Objectives:

- To make the students understand the working principle and applications of various renewable energy systems and technologies

Unit I	INTRODUCTION	9

World Energy Use – Reserves of Energy Resources – Environmental Aspects of Energy

Utilization – Renewable Energy Scenario in Tamil Nadu, India and around the World – Potentials - Achievements / Applications – Energy Storage Technologies – Mechanical energy, Electrical energy, Hydrogen Storage, Chemical energy, Thermal energy		
Unit II	**SOLAR ENERGY**	**9**
Solar Radiation – Measurements of Solar Radiation - Flat Plate and Concentrating Collectors – Solar direct Thermal Applications – Solar thermal Power Generation - Fundamentals of Solar Photo Voltaic Conversion – Solar Cells – Solar PV Power Generation – Solar PV Applications		
Unit III	**WIND ENERGY**	**9**
Wind Data and Energy Estimation – Types of Wind Energy Systems – Performance – Site Selection – Details of Wind Turbine Generator – Safety and Environmental Aspects		
Unit IV	**BIOENERGY**	**9**
Biomass – direct combustion – Biomass gasifiers – Biomass Applications – Biogas plants – Digesters – Ethanol production – Bio diesel – Cogeneration		
Unit V	**FUEL CELLS AND OTHER ENERGY SOURCES**	**9**
Basics of fuel cells – types – working – comparative analysis – performance of fuel cell – advantages and drawbacks- Hybrid Systems- Tidal energy – Wave Energy – Open and Closed OTEC Cycles – Small Hydro-Geothermal Energy		
	Total Periods	**45**
Course Outcomes: Upon successful completion of the course, students will be able to		
CO1: Explain various technologies of renewable energy and its storage (K2)		
CO2: Explain methods of power generation from solar energy (K2)		
CO3: Explain methods of power generation from wind energy (K2)		
CO4: Explain methods of power generation from bioenergy (K2)		
CO5: Explain working of fuel cells and other energy systems like tidal energy, wave energy, ocean thermal energy, hydro energy (K2)		
Text Books:		
1. G. D. Rai, Non-Conventional Energy Sources, Khanna Publishers, 1988. [ISBN: 9788174090737]		
2. R. K. Rajput, Non-Conventional Energy Sources and Utilization (Energy Engineering), S. Chand & Company, 2014. [ISBN: 9788121939713]		
References:		
1. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, PHI Learning Private Limited, 2015. [ISBN: 9788120351110]		
2. David M. Mousdale, Introduction to Biofuels, CRC Press, First edition, 2017. [ISBN: 9781138116276]		
3. Leon Freris, Wind Energy Conversion Systems, Prentice Hall, 1990. [ISBN: 9780139605277]		
4. Godfrey Boyle, Renewable Energy: Power for a Sustainable Future, Oxford University Press, Third edition, 2012. [ISBN: 9780199681273]		

Course Code	Course Title	L	T	P	C
UME2624	**SUSTAINABLE MANUFACTURING SYSTEMS**	**3**	**0**	**0**	**3**
Objectives: To introduce the various concepts associated with Design and Manufacturing for sustainability					
Unit I	**SUSTAINABILITY AND DEVELOPMENT CHALLENGES**				**9**
Definition of sustainability – Environmental, Economic and Social dimensions of sustainability					

- Sustainable Development Models – Strong and Weak Sustainability – Defining Development- Millennium Development Goals – Core problems and Cross Cutting Issues of the 21 Century - Global, Regional and Local environmental issues – Social insecurity - Resource Degradation – Climate Change – Desertification.		
Unit II	**PRINCIPLES AND FRAME WORK**	9
History and emergence of the concept of sustainable development - Our Common Future - Rio plus 20– Rio Principles of Sustainable Development – 6 R Concept, Precautionary Principle- Polluter Pays Principle – Role of Civil Society, Business and Government -Natural Step- Peoples Earth Charter and Business Charter for Sustainable Development –UN Global Compact – Product Design for Sustainability.		
Unit III	**SUSTAINABILE LIVELI HOOD**	9
Quality of Life - Poverty, Population and Pollution – Combating Poverty - Human Development Index - Demographic dynamics of sustainability - Strategies to end Rural and Urban Poverty and Hunger – Sustainable Livelihood Framework- Health, Education and Empowerment of Women, Children, Youth, Indigenous People, role of Non-Governmental Organizations in sustainable development.		
Unit IV	**SUSTAINABLE SOCIO-ECONOMIC SYSTEMS**	9
Protecting and Promoting Human Health – Investing in Natural Capital- Agriculture - sustainable agriculture, Forests, Fisheries - Food security and nutrition - Water and sanitation -Biodiversity conservation and Ecosystem integrity –Ecotourism - Urbanization and Sustainable Cities – Sustainable Habitats- Green Buildings - Sustainable Transportation – Sustainable Consumption and Production – Sustainable Energy–Mitigation and Adaptation - Safeguarding Marine Resources - Waste Management.		
Unit V	**ASSESSING PROGRESS AND WAY FORWARD**	9
Sustainability in global, regional and national context –limitations of GDP- Ecological Footprint- National initiatives for Sustainable Development -Hurdles to Sustainability – Operational guidelines –-Measuring Sustainability – Performance indicators of sustainability and Assessment mechanism – Inclusive Green Growth and Green Economy – National Sustainable Development Strategy Planning – Governance - Sustainability Education.		
	Total Periods	45
Course Outcomes: Upon successful completion of the course, students will be able to		
CO1: Explain the fundamentals of Sustainability (K2)		
CO2: Understand the history and current status of sustainability (K2)		
CO3: Summarize the concepts of sustainable livelihood (K2)		
CO4: Discuss the practical ways of following the sustainability concept (K2)		
CO5: Summarize the indices of sustainable progress (K2)		
Text Books:		
1. Paulo Davim, Sustainable Manufacturing, Wiley Publishers,1st Edition, 2010 [ISBN: 978-1-848-21212-1]		
2. Strak, Rainer, Seliger, Gunther, Sustainable Manufacturing-Challenges, Solutions and Implementation Perspectives, Springer Open Access, 2017 [ISBN: 978-3-319-48513-3]		
References:		
1. Kirkby J, O Keefe and Timberlake, Sustainable Development, Earthscan Publication, London, 1993 [ISBN: 9780367632045]		
2. UNEP, , Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication, www.unep.org/greeneconomy, 2011 [ISBN: 978-92-807-3143-9]		
3. United Nations Report, Indicators of Sustainable Development: Guidelines and		

Methodologies, New York: United Nations, 3rd Edition, 2007 [ISBN: 978-92-1-104577-2]
4. Barry Dalal Clayton and Stephen Bass, Sustainable Development Strategies-a resourcebook", Earthscan Publications Ltd, London, 2002 [SBN:1 85383 946 9]

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1					1	3	1				2		1
2	1					1	3	1				2		1
3	1					1	3	1				2		1
4	1					1	3	1				2		1
5	1					1	3	1				2		1

Course Code	Course Title	L	T	P	C
UME2721	ALTERNATIVE FUELS & EMISSION CONTROL FOR AUTOMOBILE	3	0	0	3

Objectives:

- To make the students understand engine combustion and emission characteristics by using alternative fuels like alcohols, vegetable oils and gaseous fuels
- To impart knowledge on engine emissions and their control, alternate fuels and their application in automobiles

Unit I	EMISSIONS FROM SI ENGINES AND THEIR CONTROL	9

Introduction to SI Engine Combustion, Pollutants – sources – formation (CO, HC, NOx and lead) – Effect of design and operating variables on emission formation, Effects of pollution on environment, human – Regulated & Unregulated emissions - Emission Standards - controlling of emission formation in engines, catalytic converters, charcoal canister control for evaporative emission, positive crankcase ventilation system, nanoparticles

Unit II	EMISSIONS FROM CI ENGINES AND THEIR CONTROL	9

Introduction to CI Engine Combustion, Emission formation in CI Engines (HC, CO, NOx, aldehydes, smoke and particulates) - Physical and Chemical delay - Effects of design and operating variables on emission formation – Control techniques, Fumigation, EGR, HCCI, RCCI, NOx SCR, DO-OC, DPF, NOx versus particulates tradeoff, Secondary air injection, Cetane number effect, NOx Adsorber.

Unit III	EMISSION MEASUREMENT AND TEST PROCEDURES	9

Emission measuring instruments - Principle, Operation, NDIR, FID, Chemiluminescent analyzer, Liquid and Gas Chromatography, Spot sampling and continuous indication type smoke meters (Bosch, AVL and Hartridge smoke meters) – Emission norms - EPA, CARB, Euro and Bharat norms, Emission Test Procedures - FTP, Steady State, Constant volume sampling (CVS 1 & 3), Chassis dyno - seven mode and thirteen mode cycles for emission sampling, Dilution tunnel

Unit IV	ALCOHOL FUELS AND GASEOUS FUELS	9

Properties of alcohols, alcohol - gasoline blends – flexible fuel vehicle, methanol reformed gas engine, dual fuel system, spark assisted diesel engine, surface ignition engine – ignition accelerators, oxygenated additives – Engine modifications – Performance, Combustion and Emission characteristics in SI and CI engines – Properties of hydrogen, storage methods, safety precautions, biogas production and its properties, CO2 and H2S scrubbing in Biogas, Properties of LPG and CNG – Performance, Combustion and Emission characteristics of gaseous fuels in SI and CI engines.

Unit V	VEGETABLE OILS	9
Various vegetable oils for diesel engines, structure and properties, Problems in using vegetable oils in diesel engines – engine performance improvement methods – Preheating, Transesterification, Emulsification, Blending with good secondary fuels, Production technologies for biofuels for internal combustion engines - pyrolysis, gasification, liquefaction – batch reactors – types – Performance in engines, Role of Nanofluids, additives and Cetane improvers for performance improvement of vegetable oils as fuel.		
	Total Periods	**45**

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

CO1: Explain the formation of various emissions from SI engine and control techniques (K2)

CO2: Explain the formation of various emissions from CI engine and control techniques (K2)

CO3: Explain the working of emission measuring instruments and test procedures (K2)

CO4: Explain properties of alcohol and gaseous fuels and their use in SI and CI engines (K2)

CO5: Explain properties of various vegetable oils (Biodiesel) and their use in CI engines (K2)

Text Books:

1. B. P. Pundir, IC Engines Combustion and Emissions, Narosa Publishers, 2010. [ISBN: 9788184870879]
2. Richard L Bechtold P.E., Alternative Fuels Guide book, SAE International, 1997. [ISBN: 9780768000528]

References:

1. Ganesan. V, Internal Combustion Engines, Tata McGraw Hill, Fourth edition, 2017. [ISBN: 9781259006197]
2. John B. Heywood, Internal Combustion Engine Fundamentals, McGraw Hill, First edition, 2017. [ISBN: 9781259002076]
3. Crouse.W.M. and Anglin.A.L., Automotive Emission Control, McGraw Hill, Third edition, 1983. [ISBN: 9780070148161]
4. S.S Thipse, Alternative Fuels, Jaico Publishing house, First edition, 2010. [ISBN: 9788184950786]

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3						1					1	1	
2	3						1					1	1	
3	3						1					1	1	
4	3						1					1	1	
5	3						1					1	1	

Course Code	Course Title	L	T	P	C
UME2746	ELECTRIC VEHICLES	3	0	0	3

Objectives:

- To make the students understand concepts of Hybrid and Electric Vehicles, energy storage devices and controls

Unit I	NEED FOR ALTERNATIVE SYSTEM	9
History of electric and hybrid vehicles. Need and limitations of electric vehicles (EV) –		

Comparative study with ICE vehicles – Industry growth after COVID-19 – Worldwide research and development – classification of EV architecture – BEV, HEV, PHEV, MHEV		
Unit II	**ENERGY STORAGE DEVICES**	**9**
Electromechanical batteries - Types of batteries, battery manufacturing – battery terminology – SOC, DOD, SOH – battery recycling – Battery management System (BMS), design consideration and building blocks of BMS – Electro-chemical reactions, Thermodynamic voltage, specific energy, specific power, energy efficiency and Ultra-Capacitors		
Unit III	**PROPULSION MOTORS AND CONTROLLERS**	**9**
Types of electric motors – AC, DC, PMSM, PMDC, BLDC and induction motors – characteristics of each type of motor – AC single phase and 3-phase motor – inverters – controller system in electric vehicle – DC and AC motor speed controllers – types of CAN bus – applications		
Unit IV	**ELECTRIC VEHICLES**	**9**
Electric vehicle layout, specifications, advanced materials – system components – sizing and calculation – energy conversion – electro mechanics – Electronic control system, power electronics – operation modes of 2W, 3W and 4W – power system distribution – performance of electric vehicles – traction motor characteristics, tractive effort, transmission requirements, energy consumption, safety and challenges in electric vehicles		
Unit V	**HYBRID VEHICLES**	**9**
Concept and architecture of hybrid electric drive trains – electric drive train design in series and parallel EV – Plug-in hybrid electric vehicles and Range Extended Electric Vehicles (REEV), Fuel Cell powered hybrid vehicles – fuel cell characteristics – fuel cell types – advantages – design of charging station – power protection – smart grid		
	Total Periods	**45**
Course Outcomes: Upon successful completion of the course, students will be able to		
CO1: Explain need & importance of electric vehicles and classify them (K2)		
CO2: Explain various types and methods of energy storage devices (K2)		
CO3: Explain various types and characteristics of electric motors and their controls (K2)		
CO4: Explain working principle and performance of electric vehicle and its components (K2)		
CO5: Explain working principle and architecture of hybrid vehicles (K2)		
Text Books:		
1. James Larminie and John Lowry, Electric Vehicle Technology Explained, Wiley, Second edition, 2012. [ISBN: 9781119942733]		
2. Iqbal Husain, Electric and Hybrid Vehicles-Design Fundamentals, CRC Press, 2003. [ISBN: 9780849314667]		
References:		
1. M. Ehsani, Y. Gao, S. Gay and Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, CRC Press, First edition, 2004 [ISBN: 978 0849331541]		
2. Ron Hodkinson, John Fenton, Light Weight Electric/ Hybrid Vehicle Design, Butterworth Heinemann Publication, 2001. [ISBN: 9780750650922]		
3. Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013. [ISBN: 9781461477105]		
4. Jack Erjavec & Jeff Arias, Hybrid, Electric & Fuel Cell Vehicles, Cengage Learning, First edition, 2006. [ISBN: 9781401881085]		

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												1	
2	3												1	
3	3												1	
4	3					1	1					1	1	
5	3												1	

Course Code	Course Title	L	T	P	C
UME2729	ENERGY EFFICIENT BUILDINGS	3	0	0	3

Objectives:

- To make students learn about aspects of energy efficient building design
- To impart knowledge in estimating thermal performance and incorporating renewable energy sources in buildings

Unit I	**INTRODUCTION**	**9**

Climate and Building, Historical perspective, Aspects of green building design – Sustainable Site, Water, Energy, Materials and IAQ, ECBC Standards

Unit II	**LANDSCAPE AND BUILDING ENVELOPES**	**9**

Energy efficient landscape design – Microclimate, Shading, Arbors, Windbreaks, Xeriscaping, Building envelope – Thermal comfort, Psychrometry, Comfort indices, Thermal Properties of Building Materials – Thermal Resistance, Thermal Time Constant (TTC), Diurnal Heat Capacity (DHC), Thermal Lag, Decrement Factor, Effect of Solar Radiation – Sol-air Temperature, Processes of heat exchange of building with environment, Insulation

Unit III	**PASSIVE HEATING AND COOLING**	**9**

HVAC – Passive Heating – basics of solar radiation, Sun Path Diagram, Direct Heating, Indirect Heating and Isolated heating, Concept of Daylighting, Passive Cooling – Natural Ventilation (Stack and Wind), Evaporative Cooling and Radiant cooling

Unit IV	**THERMAL PERFORMANCE OF BUILDINGS**	**9**

Heat transfer due to fenestration/infiltration, Calculation of Overall Thermal Transmittance, Estimation of building loads: Steady state method, network method, numerical method, correlations, Thermal Storage integration in buildings

Unit V	**RENEWABLE ENERGY IN BUILDINGS**	**9**

Introduction of renewable energy sources in buildings, building integrated photovoltaic systems, Solar water heating, small wind turbines, stand-alone PV systems and Hybrid system – Economics

Total Periods	**45**

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

CO1: Explain aspects of energy efficient buildings (K2)

CO2: Explain landscape parameters and elements of building envelope (K2)

CO3: Explain methods of passive heating and cooling in buildings (K2)

CO4: Explain various methods of estimating building loads and thermal performance of buildings (K2)
CO5: Explain integration of renewable energy systems in buildings (K2)
Text Books:
1. Jan F. Kreider, Peter S. Curtiss, Ari Rabl, Heating and Cooling of buildings: Design for Efficiency, Revised Second Edition, CRC Press, 2010. [ISBN: 9781439811511]
2. Charles J. Kibert, Sustainable Construction: Green Building Design and Delivery, John Wiley & Sons, Third edition, 2012. [ISBN: 9780470904459]
References:
1. Baruch Givoni, Climate considerations in building and Urban Design, Wiley, First edition, 1998. [ISBN: 9780471291770]
2. Baruch Givoni, Passive Low Energy Cooling of Buildings, Wiley, First edition, 1994 [ISBN: 9780471284734]
3. JA Duffie and WA Beckman: Solar Engineering of Thermal Processes, John Wiley & Sons, Third Edition, 2006. [ISBN: 9780471698678]
4. Ursula Eicker, Solar Technologies for buildings, Wiley, First edition, 2003. [ISBN: 9780471486374]

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3												1	
2	3						1					1	1	
3	3						1						1	
4	3												1	
5	3						1					1	1	

Course Code	**Course Title**	**L**	**T**	**P**	**C**
UME2738	**PRINCIPLES OF ENERGY CONSERVATION, AUDIT AND MANAGEMENT**	3	0	0	3

Objectives:

- To make students understand about the current energy scenario, aspects of energy conservation, energy economy and management and know the process of detailed energy audit and scope of energy conservation in different energy intensive electric/thermal utilities

Unit I	**INTRODUCTION**	**9**

Energy scenario, climate change, global warming, need and scope of energy conservation in domestic, transportation, agriculture and industrial sectors, Bureau of Energy Efficiency (BEE), Energy Policies, Energy Certification, energy Auditors, energy Managers, Green Building concepts

Unit II	**ENERGY CONSERVATION IN ELECTRICAL UTILITIES**	**9**

Basics of electrical energy usage, transformers & motors, fans, pumps and compressors, illumination and energy efficient devices– Scope for energy conservation-Case studies

Unit III	**ENERGY CONSERVATION IN THERMAL UTILITIES**	**9**

Energy efficiency opportunities – Boilers, Pipes, Steam traps, Cogeneration – Principles & operation, Assessment of steam distribution system. Performance analysis of HVAC systems. DG Set – Performance prediction – Cost of power generation – Scope for energy conservation-Case studies

Unit IV	ENERGY MANAGEMENT AND ENERGY AUDIT	9
Industrial Practices - Energy management program. Energy audit types, Audit methodology. Energy monitoring and targeting: Instruments and their usage for auditing		
Unit V	**ECONOMIC ANALYSIS**	**9**
Cost / Energy Share Diagram – Break even analysis – Depreciation – Financial analysis techniques – Cumulative Sum Control Chart Technique – Energy management information systems (EMIS) - Energy Service Companies Concept (ESCO) and Contracts-Case studies		
	Total Periods	**45**

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

CO1: Explain India's energy scenario, know about the country's energy policy, green building concepts and roles of energy auditors and BEE on energy conservation (K2)

CO2: Explain basic principles and operation of key electric utilities like transformers, motors, pumps, fans, etc. and energy conservation opportunities on the utilities (K2)

CO3: Explain basic principles and operation of key thermal utilities like boilers, steam traps, HVAC systems, etc. and energy conservation opportunities on the utilities (K2)

CO4: Apply the basic aspects of energy management and energy auditing (K3)

CO5: Explain different techniques of financial analysis and apply the same for economic assessment of projects (K3)

Text Books:

1. S. S. Thipse, Energy Conservation and Management, Alpha Science Internationals Ltd., 2014. [ISBN: 9781842659212]
2. K. Nagabhushan Raju K., Industrial Energy Conservation Techniques: Concepts, Applications and Case studies, Atlantic, 2007. [ISBN: 9788126907748]

References:

1. Barney L. Capehart, Wayne C Turner, William J. Kennedy, Guide to Energy Management, Fairmont Press, Eighth edition, 2016. [ISBN: 9781498759335]
2. Ashok Sethuraman, Practical Guide to Energy Conservation & Management, Notion Press, 2020. [ISBN: 9781636696027]
3. Udit Mamodiya, Electrical Energy Conservation & Auditing, Ashirwad Publishers, First edition, 2020. [ISBN: 9788194250692]
4. Y. Y. Haimes, Energy Auditing and Conservation; Methods Measurements, Management and Case studies, Hemisphere Publications, Washington, 1980. [ISBN: 9780891161752]

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3					3	1					1	1	
CO2	3						1					1	1	
CO3	3						1					1	1	
CO4	3	3				3						1	1	
CO5	3	3				3					3	1	1	

Course Code	Course Title	L	T	P	C
UME2822	**SOLAR ENERGY TECHNOLOGY**	3	0	0	3

Objectives:

- To make the students understand the concepts solar radiation, solar thermal,

photovoltaic technologies and passive solar architecture		
Unit I	**SOLAR RADIATION**	**9**
Basic laws of radiation and components of sun's radiation. Sun-earth relationships, sun-path diagram, Extraterrestrial radiation, air mass, measurement of solar radiation-pyranometer, pyrheliometer and sunshine recorder, solar angles- Sunrise, sun set time and day length, Estimation of solar radiation on horizontal and tilted surfaces.		
Unit II	**SOLAR THERMAL COLLECTORS**	**9**
Flat plate collectors – construction and materials. Efficiency of flat plate collectors, concentrating collectors, concentration ratio, Compound parabolic concentrators, parabolic trough concentrators, concentrators with point focus – Heliostats. Evacuated tubular collectors. Solar tracking systems.		
Unit III	**SOLAR THERMAL APPLICATIONS**	**9**
Solar heating systems – water and air heating systems. Solar vapour absorption cooling system. Thermal Energy storage systems. Solar Desalination, Solar pond, Solar cooker and Solar drying systems.		
Unit IV	**SOLAR PHOTOVOLTAICS**	**9**
Semiconductor and Solar cell, solar cell characteristics, efficiency limits, variation of efficiency with band-gap and temperature, high efficiency cells. Solar module and array, Storage autonomy, centralized and decentralized SPV systems, stand alone, hybrid and grid connected system. Balance of system.		
Unit V	**SOLAR PASSIVE ARCHITECTURE**	**9**
Thermal comfort, bioclimatic classification. Passive heating concepts- direct and indirect heat gain, isolated gain and sunspaces. passive cooling concepts- evaporative cooling, Radiative cooling, shading, cavity walls, roof radiation traps, earth air-tunnel, energy efficient landscape design.		
	Total Periods	**45**
Course Outcomes: Upon successful completion of the course, students will be able to		
CO1: Explain the fundamentals of solar radiation and solve simple problems (K2)		
CO2: Explain the working of various solar thermal collectors and tracking systems (K2)		
CO3: Explain the applications of solar thermal systems (K2)		
CO4: Explain the working of various solar photovoltaic systems (K2)		
CO5: Explain passive heating as well as cooling concepts and various solar passive techniques (K2)		
Text Books:		
1. S. P. Sukhatme, J. P. Nayak, Solar Energy: Principles of Thermal Collection and Storage, McGraw Hill Education, Third edition, 2009. [ISBN: 9780070142961]		
2. G. N. Tiwari, Solar Energy: Fundamentals, Design, Modelling and Applications, Narosa Publishing House Pvt. Ltd., 2012. [ISBN: 9788184872774]		
References:		
1. H. P. Garg, and J. Prakash, Solar Energy: Fundamentals and Applications, McGraw Hill Education, First edition, 2017. [ISBN: 9780074636312]		
2. D. Y. Goswami, F. Kreith, J. F. Kreider, Principles of Solar Engineering, CRC Press, Second edition, 2000. [ISBN: 9781560327141]		
3. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, PHI Learning Private Limited, 2015. [ISBN: 9788120351110]		
4. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, Wiley, Fourth edition, 2013. [ISBN: 9780470873663]		

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3					1						1	
2	3	2					1					1	1	
3	3	1					1					1	1	
4	3	1					1					1	1	
5	3	1					1					1	1	

Mapping of courses with SDGs – B.E. Biomedical Engineering

Subject Name	SDG																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tissue Engineering			✓						✓								✓
Artificial Organs			✓						✓								✓
Hospital waste management			✓								✓						
Robotics in medicine									✓								✓
Genetic Engineering			✓						✓								✓
Regenerative medicine			✓						✓								✓
Nanoparticles and drug delivery systems			✓						✓								✓
Clinical Engineering			✓						✓								✓
Disaster Science and management											✓		✓		✓		

COURSE CODE	COURSE TITLE	L	T	P	C
UBM2623	TISSUE ENGINEERING	3	0	0	3

COURSE OBJECTIVES

The objective of this course is to enable the student to

- Understand the basics of Tissue Engineering
- Understand the fundamentals of cell mechanisms
- Provide the Physical & biological principles for understanding the interactions of biological molecules and cells
- Impart the knowledge on scientific basis of biomaterials employed for the fabrication of permanent implantable prostheses and as matrices for tissue engineering.
- Understand the various applications of Tissue Engineering

UNIT I INTRODUCTION 9

Introduction to Tissue Engineering - Objectives of Tissue Engineering - Basic definitions - Structure and organization of Tissues – Development of Tissue – Tissue exchange and diffusion of simple metabolites – Tissue Equivalent - Wound Healing Process - Biocompatibility and toxicity assessment.

UNIT II FUNDAMENTALS OF CELL MECHANISMS 9

Cell adhesion, Cell migration and Cell aggregation – Cell growth and Cell cycle. Cellular Interactions: Cell – Cell and Cell – Matrix. Control of Cell migration in Tissue Engineering –Cell delivery and Recirculation – Cell Culture in vitro – 3D culture in Tissue Engineering - In vitro Organogenesis - Cell transplantation.

UNIT III BIOMATERIALS 9

Definition – Biological vs Non biological materials – Extra Cellular Matrix – Collagen, Chitin & Degradable and Non degradable materials – Polymer, Ceramics and Metals – Cell interaction with different materials –- Scaffolds - Control releaser agents in Tissue Engineering – Cell interaction with suspension and gels – Tissue response to implants.

UNIT IV STEM CELLS APPLICATION 9

Introduction of Stem cells – Hem poetic Stem cells - Embryonic Stem cells - Adult stem cells – Cancer Stem cells – Cord Blood cells – Induced Pluripotent Stem cells - Stem cell identification - Surface markers & FACS analysis – Differentiation, Dedifferentiation and Immortalization – Application of stem cells in tissue Engineering.

UNIT V TISSUE ENGINEERING APPLICATIONS 9

Synthetic components – Artificial organs – Joints and dental prostheses - Connective Tissue Engin eering – Cardiovascular Tissue Engineering – Neural Tissue Engineering - Cell and Drug Delivery systems.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon successful completion of the course, students will be able to

CO1: Relate the importance of tissue engineering in the field of biomedical engineering.
CO2: Explain the mechanisms involved in the interaction of different materials with cells and tissues
CO3: Illustrate the different methods involved in characterization and preparation of biomaterials in tissue engineering.
CO4: Demonstrate different types of stem cells and its application in tissue engineering
CO5: Utilize the knowledge in creating new models in drug delivery systems using synthetic and natural scaffolds

TEXTBOOKS

1. W. Mark Saltzman Tissue Engineering – Engineering principles for design of replacement organs and tissue, Oxford University Press Inc. New York, 2004.
2. Sujata V.Bhatt, Biomaterials (2nd Edition), Narosa Publishing House, 2005.
3. R.Lanza, J.Gearhart et.al,(Eds), Essential of Stem cell Biology, Elsevier Academic Press, 2006.Develop new approaches to build new tissues using tissue engineering techniques

REFERENCES

1. Gray E Wnek, Gray L Browlin, Encyclopaedia of Biomaterials and Biomedical Engineering – Marcel Dekker Inc. New York, 2004.
2. Lanza R, Weissman I, Thomson J and Pedersen P, Handbook of Stem Cells, TwoVolume, Volume 12: Volume 1.Embryonic Stem Cells; Volume 2. Adult & Fetal Stem Cells, Academic Press, 2002.
3. Joseph D. Bronzino, Tissue Engineering and Artificial Organs, 3rd edition, CRC press, 2006.

ONLINE RESOURCES

1. https://nptel.ac.in/courses/102/106/102106081/
2. https://www.classcentral.com/course/tissue101-494

CO-PO/PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2		2									3		
CO2	3	2		2									3		
CO3	3	2		2									3		
CO4	3	2		2									3		
CO5	3	2		2									3		

COURSE CODE	COURSE TITLE	L	T	P	C
UBM2624	ARTIFICIAL ORGANS	3	0	0	3

COURSE OBJECTIVES

The objective of this course is to enable the student to

- Provide basic knowledge on the design of bone fixation device.
- Study artificial eye and its replacement.
- Understand artificial lung and its replacement.
- Understand total artificial heart & heart valves.
- Study artificial kidney, liver, pancreas and its replacement.

UNIT I THE DESIGN OF A BONE FRACTURE-FIXATION DEVICE 9

Shoulder joint and its artificial replacement, elbow joint and its artificial replacement, wrist joint and its artificial replacement, finger joint and its artificial replacement, Hip, Knee & ankle joints and its artificial replacement.

UNIT II THE EYE AND ITS ARTIFICIAL REPLACEMENT 9

Anatomy of the Eye, Development of the Eye, Disorders of the Eye, Implantation - implantable contact lenses, LASIK Eye Surgery, Diagnosis/Preparation, after care, risks, alternative**s**

UNIT III THE LUNG AND ITS ARTIFICIAL REPLACEMENT 9

Respiratory Tract, Path Traced by Inhaled Air, Common Lung Diseases, Lung Transplantation, Types of Lung Transplants, Design of Artificial Lungs

UNIT IV DESIGN OF THE TOTAL ARTIFICIAL HEART & HEART VALVE 9

Cardio West Temporary Total Artificial Heart, AbioCor Replacement Heart, Early Designs of Total Artificial Hearts, First Clinical Applications of a Permanent Pneumatic Total Artificial Heart, The Development of Permanent, Implantable, Electrically Powered Artificial Hearts, Artificial Heart Valves, Potential Risks of Artificial Heart Valves, Lifestyle Considerations, Sterilization and Packaging & quality control.

UNIT V THE KIDNEY, LIVER, PANCREAS AND ITS ARTIFICIAL REPLACEMENT 9

Chronic Kidney Disease (CKD) and Related Facts, the Artificial Kidney, Coil Hemodialyzer, Endocrine Physiology, Artificial Pancreas, Bioengineering Approach to an Artificial Pancreas, Bioartificial Liver Device, Progress toward an Artificial Liver Transplant

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon successful completion of the course, students will be able to

CO1: Ascertain the concepts of bone fixation technique.
CO2: Appraise the use of artificial eye and its replacement.
CO3: Analyze and design artificial lung and its replacement.
CO4: Figure the use of total artificial heart & heart valve.
CO5: Investigate the use of artificial kidney, liver, pancreas and its replacement.

TEXTBOOKS

1. Subrata Pal, "Design of Artificial Human Joints & Organs", Springer, 2014
2. Gerald Miller, "Artificial Organs", Morgan & Claypool Publishers, 2006.
3. Michael Lysaght, Thomas Webster, "Biomaterials for Artificial Organs", Woodhead Publishing, 2011.

REFERENCES

1. Joseph D. Bronzino, "Tissue Engineering and Artificial Organs", CRC Press, 2006.
2. Michael Devile, Nadey S. Hakim, "Artificial Organs", Springer-Verlag London, 2009.
3. Larry L. Hench, Julian R. Jones, "Biomaterials, artificial organs and tissue engineering", CRC Press, 2005.
4. Kolff W.J, Artificial Organs, John Wiley and sons, New York, 1st edition, 1976.

ONLINE RESOURCES

1. https://nptel.ac.in/courses/102/106/102106057/

CO-PO/PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3			3				3		3	3		3
CO2	3	2	3			3				3		3	3		3
CO3	3	2	3			3				3		3	3		3
CO4	3	2	3			3				3		3	3		3
CO5	3	2	3			3				3		3	3		3

COURSE CODE	COURSE TITLE	L	T	P	C
UBM2626	HOSPITAL WASTE MANAGEMENT	3	0	0	3

COURSE OBJECTIVES

The objective of this course is to enable the student to:

- Get introduced to the different types of wastes generated in a hospital
- Understand the hazards of hospital waste
- Familiarize with medical waste handling
- Apprised with training of healthcare workers in waste handling
- Have knowledge of infectious waste management

UNIT I INTRODUCTION 9

Introduction, Types of wastes – Waste, General Waste, Biomedical Waste, Major and minor sources of Biomedical Waste – Waste generation, Categories and classification of Biomedical Waste – Objectives,

Categories, Classification

UNIT II HAZARDS OF HOSPITAL WASTE 9

Hazards of Biomedical Waste, Need of Disposal of Biomedical Waste – Health reasons, Ethical aspects, Environmental Reasons, Waste Minimization – Need, Advantages, Procedures, Waste segregation and labelling- Requirements, Persons responsible, Procedure, Rules, Advantages, Containers, Labelling

UNIT III MEDICAL WASTE HANDLING 9

Waste handling, Collection, Storage and Transportation, Treatment and disposal – Waste treatment, Category wise management, Methods for treatment, Landfill, Dental office waste – mercury containing wastes, silver containing wastes, Lead containing wastes, Biomedical Wastes, Chemicals, disinfectants and sterilizing agents, Pollution prevention for dentists

UNIT IV TRAINING OF HEALTHCARE WORKERS 9

Training of healthcare workers – Aims, recommendations, waste transport staff, Operators of treatment plants, Immunization of healthcare workers – Management of occupational blood exposure, Hepatitis A and B, Prophylaxis, HIV PEP, HCV, H1N1, Infection control practices in waste management

UNIT V INFECTIOUS WASTE MANAGEMENT 9

Identifying infectious waste, Types of infectious waste, Human blood and blood products, Cultures and stocks of infectious agents, Pathological wastes, Contaminated sharps, Contaminated laboratory wastes, Contaminated wastes from patient care, Discarded biological, Contaminated equipment, Miscellaneous.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon successful completion of the course, students will be able to

CO1: Explain about different types of wastes generated in a Hospital
CO2: Describe the hazards of hospital waste
CO3: Elucidate their knowledge on medical waste handling
CO4: Comment on training of healthcare workers on waste management
CO5: Give an account of infectious waste management

TEXT BOOKS

1. Antarpreet Singh and Sukhjeet Kaur, Biomedical Waste Disposal, Jaypee Brothers, 2012
2. Shishir Baskar, Hospital Waste Management Agsar: A guide for self-assessment and review, Jaypee, 2009
3. Madhuri Sharma, Hospital Waste Management and its monitoring, Jaypee, 2017

REFERENCES

1. Jack Watson, Separation Methods for waste and environmental applications, Marcel Dekker, 1999
2. Saxena A, Hospital waste management: Principles and practices, Navyug books international, 2012
3. Chandra Ballabh, Hospital Waste Management, Alfa Publications, 2007

ONLINE RESOURCES

1. https://www.coursera.org/lecture/engineering-humanitarian/medical-waste-management-part-a-GsFYz
2. https://dth.ac.in/medical/courses/Microbiology/block-9/3/index.php

CO-PO/PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						3	2		2	3		3	3		3
CO2						3	2	2	2	3		3	3		3
CO3						3	2		2	3		3	3		3

CO4						3	2		2	3		3	3		3
CO5						3	2		2	3		3	3		3

COURSE CODE	COURSE TITLE	L	T	P	C
UBM2721	ROBOTICS IN MEDICINE	3	0	0	3

COURSE OBJECTIVES

The objective of this course is to enable the student to:

- Get introduced to the fundamental of robotics and position analysis
- Learn about Parallel robots, different types of motions and force analysis
- Know the basics of trajectory planning, Motion control systems and actuators
- Have an insight into various sensors and vision systems
- Be acquainted to Fuzzy control and Applications of Robotics in Medicine

UNIT I FUNDAMENTALS AND POSITION ANALYSIS 9

Fundamentals – Classification, Advantages and disadvantages, Components, Degrees of freedom, Joints, Coordinates, Reference frames, Programming modes, Characteristics, Workspace, Languages, Collaborative robots, Position analysis – Robots as mechanisms, Conventions, Transformations, Forward and inverse kinematics, Denavit Hartenberg Representation, Degeneracy and Dextrerity, Screw based robots, Position analysis of Articulated robot

UNIT II PARALLEL ROBOTS, DIFFERENTIAL MOTIONS AND FORCE ANALYSIS 9

Parallel robots – Physical characteristics, Forward and Inverse Kinematic approaches, Planar and Spatial parallel robots, Differential relationships, The Jacobian, Large scale motions, Frame vs Robot, Differential motions and change, Hand frame, Operator, Jacobian and Inverse for Screw based and Parallel Robots, Differential operator, Lagarangian mechanics, Moments of Inertia, Dynamic Equations of Multiple DOF Robots, Static force analysis, Transformation of forces and moments between coordinate frames

UNIT III TRAJECTORY PLANNING, MOTION CONTROL SYSTEMS AND ACTUATORS 10

Path and Trajectory, Joint Space and Cartesian Space Descriptions and Trajectory Planning, Cartesian, Trajectory Recording, Basics, Block diagrams, Laplace Transform, Block diagram Algebra, Transfer Functions, Characteristic equation, Steady state error, Root locus, Proportional, Integral and Derivative controllers, Compensators, Bode, Loops, Multiple IO systems, Control - State space and Digital, Nonlinear systems, Characteristics of Hydraulic, Pneumatic, Electric motors, Other actuators, Speed reduction

UNIT IV SENSORS, IMAGE PROCESSING AND ANALYSIS WITH VISION SYSTEMS 9

Sensor Characteristics, Position, Velocity, Acceleration, Force, Pressure and Torque, Microswitches, Visible and IR, Touch, Proximity, Range finders, Sniff, Vision, Transforms – Fourier, Hough, Resolution, Quantization, Sampling, Image processing, Segmentation, Region growing and splitting, Operations, Object recognition, Depth, Specialized lighting, Compression, Colour images, Heuristics,

UNIT V FUZZY CONTROL AND APPLICATIONS IN MEDICINE 8

Fuzzy control - Crisp vs Fuzzy, Sets, Inference rules, Defuzzification, Simulation, Applications in Biomedical Engineering, Applications in rehabilitation, Nanobots in medicine, Clinical diagnosis and Surgery – Cardiac and abdominal procedures with teleoperated robots, Orthopedic surgery with cooperative robots

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon successful completion of the course, students will be able to

CO1: Describe the fundamental of robotics and position analysis
CO2: Outline the functioning of parallel robots, different types of motions and force analysis.
CO3: Portray the basics of trajectory planning, Motion control systems and actuators.
CO4: Recognize and explain the use of various sensors and vision systems in robotics.
CO5: Employ Fuzzy control in robotics and apply it to Robotics in Medicine

TEXT BOOKS

1. S. B. Niku, Introduction to Robotics, Analysis, Control, Applications, Pearson Education, 2020
2. Robert Schilling, Fundamentals of Robotics-Analysis and control, Prentice Hall of India, 2003.
3. Fu Gonzales and Lee, Robotics, McGraw Hill, 1987.
4. J Craig, Introduction to Robotics, Pearson Education, 2005.

REFERENCES

1. Grover, Wiess, Nagel and Oderey, Industrial Robotics, McGraw Hill, 2012.
2. Klafter, Chmielewski and Negin, Robot Engineering, Prentice Hall Of India, 1989.
3. Mittal, Nagrath, Robotics and Control, Tata McGraw Hill publications, 2003.
4. Bijay K. Ghosh, Ning Xi, T.J. Tarn, Control in Robotics and Automation Sensor – Based integration, Academic Press, 1999.
5. Mikell P. Groover, Mitchell Weiss, Industrial robotics, technology, Programming and Applications, McGraw Hill International Editions, 1986.
6. Richard D. Klafter, Thomas A. Chmielewski and Michael Negin, Robotic engineering - An Integrated Approach, Prentice Hall Inc, Englewoods Cliffs, NJ, USA, 1989.

ONLINE RESOURCES

1. https://www.coursera.org/lecture/ghi-healthcare-innovation-what-success-look-like-how-to-achieve/robotic-surgery-interview-with-hutan-ashrafian-QIUBV
2. https://onlinecourses.nptel.ac.in/noc21_me49/preview

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	3	2			3		3	3	2	3
CO2	3	3	2	3	3	3	2			3		3	3	2	3
CO3	3	3	2	3	3	3	2			3		3	3	2	3
CO4	3	3	2	3	3	3	2			3		3	3	2	3
CO5	3	3	2	3	3	3	2			3		3	3	2	3

COURSE CODE	COURSE TITLE	L	T	P	C
UBM2739	GENETIC ENGINEERING	3	0	0	3

COURSE OBJECTIVES

The objective of this course is to enable the student to

- Introduce basic principles in genetic engineering.
- Provide the details on enzymes in genetic engineering.
- Impart the knowledge of nucleic acid in genetic engineering.
- Disseminate a foreword on Gene Transfer technology.
- Understand the microbial genetic engineering and bio pharming.

UNIT I INTRODUCTION 9

Role of genes within cells, genetic code, genetic elements that control gene expression, Method of creating

recombinant DNA molecules, Types, biology and salient features of vectors in recombinant DNA technology–I: Plasmids, Phages, Cosmids, Fosmids, Phagemids, and Artificial chromosomes, Safety guidelines for recombinant DNA research, Control of spills and mechanism of implementation of bio safety guidelines.

UNIT II ENZYMES 9

Enzymes in genetic engineering: Restriction nucleases: exo & endo nucleases, Enzymes in modification- Polynucleotide phosphorylase, DNase and their mechanism of action, Enzymes in modification- Methylases and phosphatases and their mechanism of action, Enzymes in modification- Polynucleotide kinase, Ligases, RNase and their mechanism of action.

UNIT III NUCLEIC ACIDS 9

Methods of nucleic acid detection, Polymerase chain reaction (PCR) and its applications, Variations in PCR and their applications, Methods of nucleic acid hybridization, Probe and target sequences, Nucleic acid mutagenesis in vivo and in vitro, Isolation and purification of nucleic acid (genomic/plasmid DNA and RNA), Quantification and storage of nucleic acids, Construction of cDNA library, Construction of Genomic library, Screening and preservation of DNA libraries, DNA Sequencing and cloning strategies.

UNIT IV GENE TRANSFER 9

Gene transfer techniques: biological methods, Gene transfer techniques: chemical methods, Gene transfer techniques: physical or mechanical methods, Agrobacterium- mediated gene transfer in plants, Chloroplast transformation, Gene therapy: Introduction and Methods, Gene targeting and silencing, Gene therapy in the treatment of diseases, Challenges and future of gene therapy.

UNIT V MICROBIAL BIOTECHNOLOGY AND BIOPHARMING 9

Microbial biotechnology: Genetic manipulation, Engineering microbes for the production of antibiotics and enzymes, Engineering microbes for the production of insulin, growth hormones, monoclonal antibodies, Engineering microbes for clearing oil spills, Transgenic science in plant improvement, Biopharming - plants as bioreactors, Transgenic science for animal improvement, Biopharming- Animals as bioreactor for recombinant protein, Gene mapping in plants and animals, Marker-assisted selection for plant breeding and livestock improvement

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon successful completion of the course, students will be able to

CO1: Explain basic principles in genetic engineering.
CO2: Exhibit their knowledge of enzymes in genetic engineering.
CO3: Display the knowledge of nucleic acid genetic engineering.
CO4: Give details of Gene Transfer technology.
CO5: Describe the microbial genetic engineering and bio pharming.

TEXT BOOKS

1. Nicholl, An Introduction to Genetic Engineering, Cambridge Low Price Edition, 2006.
2. Primrose S.B and Twyman R.M, Principles of gene manipulation and Genomics, Blackwell Scientific Publications, 2008.
3. Benjamin Lewis, Genes IX, Oxford University and Cell Press, 2008.

REFERENCES

1. A.J. Nair, Introduction to Biotechnology and Genetic Engineering, Infinity Science Press, 2008
2. Benjamin A. Pierce, Genetics A Conceptual Approach, WH Freeman and Co., 2012

ONLINE RESOURCES

1. https://www.coursera.org/lecture/dna-decoded/genetic-engineering-KIRoE
2. https://nptel.ac.in/courses/102/103/102103013/

CO-PO/PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3

CO1	3	3	3	3	2					3			3	2	3
CO2	3	3	3	3	2					3			3	2	3
CO3	3	3	3	3	2					3			3	2	3
CO4	3	3	3	3	2					3			3	2	3
CO5	3	3	3	3	2					3			3	2	3

COURSE CODE	COURSE TITLE	L	T	P	C
UBM2731	REGENERATIVE MEDICINE	3	0	0	3

COURSE OBJECTIVES

The objective of this course is to enable the student to

- Get introduced to the fundamental of cell culture and stem cells
- Learn about 3D bioprinting and Nanotechnology
- Understand the basics of therapeutic uses of stem cells in regenerative medicine
- Have an insight into mechanics of tissue development
- Be acquainted to application of regenerative medicine in treating diseases

UNIT I CELL CULTURE AND STEM CELLS 9

Molecular organization of cells, Cell culture - 2D and 3D, Tissue specific Extracellular Microenvironment, Cell-Cell, Effecter and ECM Interaction, ECM related disorders, ECM mimicking for 3D cell Culture, Scaffolds and matrices for 3D cell and Tissue culture, Available technologies

UNIT II 3D BIOPRINTING AND NANOTECHNOLOGY 9

Nanotechnology as a toolkit for cell behavior, 3D printing and nano manufacturing, 3D bioprinting techniques, CAD/CAM laser bioprinting, Laser direct write, Biomaterials for bioprinting, Blood vessel regeneration, Vasculature patterning, Craniofacial and dental tissue, Additive manufacturing

UNIT III THERAPEUTIC USES OF STEM CELLS IN REGENERATIVE MEDICINE 9

Sources of stem cells, Hematopoietic stem cells, Mesenchymal stem cells, Cell therapy for liver disease, Cardiac stem cells, Skeletal muscle stem cells, Peripheral blood, Pancreatic islets - Regenerative strategies for treatment of diabetes, Retina, Traumatic brain injury

UNIT IV MECHANICS OF TISSUE DEVELOPMENT 9

Mechanical determinants of tissue development, Morphogenesis, Bone Morphogenetic Proteins and Regeneration of bone and Articular cartilage, Physical stress, Natural origin materials for bone tissue engineering, Calcium phosphate bio ceramics and Cements, Biocompatibility and bio response to Biomaterials

UNIT V REGENERATIVE MEDICINE TREATMENTS 9

Body on a chip, Hair cell regeneration in inner ear and lateral line, Blood substitutes, Transplantation – Myoblast, Islet cell, Gene based therapies, Engineering of large diameter vessels, Tissue engineered heart valves, respiratory tract, Cardiac tissue, Liver tissue, Cornea, Alimentary tract, Renal replacement, Central nervous system, Peripheral nerves, Reproductive system, Sports and Orthopedics.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon successful completion of the course, students will be able to

CO1: Describe the fundamentals of cell culture and stem cells.

CO2: Explain the process of 3D Bioprinting.
CO3: Demonstrate their knowledge of therapeutic uses of stem cells.
CO4: Summarise the mechanics of tissue development.
CO5: Expound about the treatments based on regenerative medicine.

TEXTBOOKS

1. Ranjana C. Dutta and Aroop K. Dutta; 3D Cell Culture, Fundamentals and Applications in Tissue Engineering and Regenerative Medicine, Pan Stanford Publishing, 2018
2. Lijie G. Zhang, John P. Fisher and Kam W. Leong, 3D Bioprinting and Nanotechnology in Tissue Engineering and regenerative Medicine, Elsevier, 2015
3. Anthony Atala, Robert Lanza, Antonios G. Mikos and Robert Nerem, Principles of Regenerative Medicine, Third Edition, Elsevier, 2019

REFERENCE

1. Gerard A. Manga and Victor Ibrahim, Regenerative Treatments in Sports and Orthopaedic Medicine, Demos Medical, Springer, 2018

ONLINE RESOURCES

1. https://nptel.ac.in/content/storage2/courses/104108056/module7/PNR%20lecture%2028.pdf

CO-PO/PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		2	2					3		3	3	2	3
CO2	3	3		2	2					3		3	3	2	3
CO3		3		2	2					3		3	3	2	3
CO4	3	3		2	2					3		3	3	2	3
CO5	3	3		2	2					3		3	3	2	3

COURSE CODE	COURSE TITLE	L	T	P	C
UBM2732	NANO PARTICLES AND DRUG DELIVERY SYSTEMS	3	0	0	3

COURSE OBJECTIVES

The objective of this course is to enable the student to

- Introduced to various basics of drug delivery
- Acquainted with various drug delivery systems for different body systems
- Accustomed with nanoparticles as drug delivery systems
- Informed about physical characterization of nano-drug delivery systems.
- Primed about the biocompatibility of nano-drug delivery system

UNIT I INTRODUCTION 9

Factors that impact the develop ability of drug candidate, Physiological, biochemical and chemical barriers to oral drug delivery, Physicochemical properties, formulation and drug delivery, targeted Bioavailability, Role of transporters in drug delivery and excretion, intracellular delivery and deposition of small molecular weight drugs, pre-systemic and first pass metabolism, Evolution of controlled drug delivery systems, Metabolic activation and Drug targeting

UNIT II DRUG DELIVERY IN HUMAN BODY SYSTEMS 9

Pulmonary drug delivery, Transdermal delivery of drugs – patches and patchless, Prodrug approach, Central

nervous system, Colon, Protein and peptide conjugates to target specific cells, Lymphatic system, Intracellular delivery of proteins and peptides, Vaccine delivery, Delivery of genes and oligonucleotides, Receptor mediated drug delivery

UNIT III NANOPARTICLES AS DRUG DELIVERY VEHICLES 9

Key aspects of Nanotechnology and drug delivery, Liposomes as drug delivery vehicles, Polymeric nanomaterials, Nano-sized polymeric drug carrier systems, Reversible cross linked polymeric nanoplatform in drug delivery, Cyclodextrins, Tyrosine derived nanospheres, Carbon nanotubes, Metallic Nano particulate, Porous silicate, Iron oxides, Nano engineered Magnetic field-induced drug delivery

UNIT IV PHYSICAL CHARACTERIZATION 9

Benefits of Nanotechnology to drug delivery, Challenges of Nanoparticle characterization, Regulatory review of Nano therapeutics, Assays to determine Physical and Chemical Properties– Hydrodynamic properties, Matrix assisted laser desorption ionization time-of-flight mass spectroscopy, Zeta potential, Atomic force microscopy, Free Gandolium for MRI imaging, Lipid component quantization by Thin Layer Chromatography

UNIT V BIOCOMPATIBILITY 9

Sterility Assays – Endotoxin contamination, Microbial contamination, In Vitro Detection and Quantization – Gold nanoparticle Quantization via fluorescence in solution and cell culture, Monitoring Hepatocarcinoma cells for apoptosis, Reactive Oxygen Species, Lipid peroxidation, Glutathione homeostasis, Lysosomal activity, In Vitro Immunological Assays – Hemolytic, Thrombogenic, Compliment activation, Cellular chemotaxis, Macrophage uptake properties.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon successful completion of the course, students will be able to

CO1: Explain the basics of drug delivery.
CO2: Illustrate the drug delivery systems for different body systems.
CO3: Demonstrate the use of different nanoparticles as drug delivery vehicles.
CO4: Outline physical characterization of nano-drug delivery systems.
CO5: Explain the various biocompatibility testing methods of nano-drug delivery systems.

TEXTBOOKS

1. Binghe Wang, Longqin Hu and Teruna J. Siahaa, Drug Delivery-Principles and Applications, John Wiley and Sons, Inc., 2016.
2. José L. Arias, Nanotechnology andDrug Delivery-Volume 1: Nanoplatforms in Drug Delivery, CRC Press, 2015.
3. Scott E. McNeil, Methods in Molecular Biology, Characterization of Nanoparticles Intended for Drug Delivery, 2011.

REFERENCES

1. Vasant V. Ranade and John B. Cannon, Drug Delivery Systems, CRC Press, 2011.
2. Arun Kumar, Heidi M. Mansour, Adam Friedman and Eric R. Blough, Nanomedicine in Drug Delivery, CRC Press, 2017.
3. De Villiers, Melgart M., Aramwit, Pornanong, Kwon, Glen S., Nanotechnology in Drug Delivery, Springer, 2009.

ONLINE RESOURCES

1. https://nptel.ac.in/courses/102/107/102107058/
2. https://nptel.ac.in/courses/102/108/102108077/

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2										1	3		2
CO2	3	2	2									1	3		2
CO3	3	2	2									1	3		2
CO4	3	2	2		2							1	3		2
CO5	3	2	2		2							1	3		2

COURSE CODE	COURSE TITLE	L	T	P	C
UBM2825	CLINICAL ENGINEERING	3	0	0	3

COURSE OBJECTIVES

The objective of this course is to enable the student to

- Understand the fundamentals of clinical engineering practices.
- Explain the technology used to establish healthcare management
- Explore various private and public health policies
- Learn various information regulatory system
- Understand the safety measures in the establishment of clinical environment

UNIT I INTRODUCTION 9

Clinical Engineering: Evolution of a Discipline -History of engineering and technology in health care - health care environment - Enhancing Patient Safety: The Role of Clinical Engineering - A Model Clinical Engineering Department clinical engineering department. Clinical Engineering in an Academic Medical Center in academic medical center - careers, roles and responsibilities.

UNIT II HEALTH TECHNOLOGY MANAGEMENT 9

Introduction to Medical Technology Management Practices, Good Management Practice for Medical Equipment- Health Care Strategic Planning Utilizing Technology Assessment, Technology Evaluation – Procurement, Equipment Control and Asset Management, Computerized Maintenance Management Systems, Outsourcing Clinical Engineering Service, Vendor and Service Management, Donation of Medical Device Technologies.

UNIT III HEALTH POLICY 9

Definition of Health and Health Policy - Need for evolving health policy - health organization in the state - - Health education - Health insurance - Health legislation - National health technology policy – Employment State Insurance Scheme (ESIS) - Central Government Health Scheme (CGHS), Planning in India: Five-Year Plans – objectives, priorities and problems.

UNIT IV INFORMATION MANAGEMENT IN HOSPITALS 9

Information Systems Management, Physiologic Monitoring and Clinical Information Systems, Advanced Diagnostics and Artificial Intelligence, Telemedicine: Clinical and Operational Issues, Picture Archiving and Communication Systems (PACS), Wireless Medical Telemetry, Health Insurance Portability and Accountability Act (HIPAA). The Integration and Convergence of Medical and Information Technologies.

UNIT V ENGINEERING THE CLINICAL ENVIRONMENT 9

Physical plant - heating - ventilation - air conditioning - electrical power - medical gas system - support services - sanitation - water systems in hospitals - disaster planning, Virtual Instrumentation—Applications to Health Care, Clinical Engineers in Non-Traditional Roles, Clinical Support: The Forgotten Function, The

Future of Clinical Engineering: The Challenge of Change - Global Hospital in 2050—A Vision

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon successful completion of the course, students will be able to

CO1: Disseminate the fundamentals of clinical engineering practices.
CO2: Apply technology for healthcare management
CO3: Summarize various health policies
CO4: Analyse various information regulatory system
CO5: Formulate safety measure for clinical environment

TEX BOOKS

1. Joseph Dyro, "Clinical Engineering Handbook", Elsevier Academic Press, USA, 2004.
2. Goyal R C, "Human Resource Management in Hospitals", Prentice Hall of India, New Delhi 2004.

REFERENCES

1. Yadin David, Wolf W Von Maltzahn, "Clinical Engineering", CRC Press, New York, 2003.
2. B Jacobson; J G Webster, Medicine and clinical engineering, Englewood Cliffs : Prentice-Hall, 1977
3. C.A. Caceres, Practice of Clinical Engineering (Clinical engineering series), Academic Press Inc (Sept. 1977)
4. Harold E. Smalley, "Hospital Management Engineering – A guide to the improvement of hospital management system", PHI, 1982

ONLINE RESOURCES

1. https://www.udemy.com/course/healthcarelot201/
2. https://www.udemy.com/course/hlot-101-becoming-a-healthcare-administrator/

CO-PO/PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3			2				3					
CO2	3	2	3			2				3				2	2
CO3	3	2	3			2				3					
CO4	3	2	3			2				3				2	2
CO5	3	2	3			2				3					2

COURSE CODE	COURSE TITLE	L	T	P	C
UBM2826	DISASTER SCIENCE AND MANAGEMENT	3	0	0	3

COURSE OBJECTIVES

The objective of this course is to enable the student to

- Provide an exposure to basics of disaster and its types.
- Understand the repercussions of disasters and hazards
- Familiarize the strengths and weaknesses of disaster management approaches
- Explore the critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Understand the standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.

UNIT I INTRODUCTION TO DISASTERS 9

Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude; Disaster cycle, climate change disasters, Urban disaster, global trends in disasters.

UNIT II IMPACTS OF DISASTERS AND HAZARDS 9

Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts, Differential impacts: in terms of caste, class, gender, age, location, disability.

UNIT III DISASTER PRONE AREAS IN INDIA 9

Hazard and vulnerability profile of India, Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post-Disaster Diseases and Epidemics, IPCC scenario and scenarios in the context of India.

UNIT IV DISASTER PREPAREDNESS AND RISK MANAGEMENT 9

Structural and nonstructural measures, Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and Other Agencies, Media Reports: Governmental and Community Preparedness. Disaster management Act and Policy

UNIT V DISASTER MANAGEMENT: APPLICATIONS AND CASE STUDIES 9

Case studies: Landslide Hazard Zonation, Earthquake Vulnerability Assessment of Buildings and Infrastructure, Drought assessment, Coastal flooding Storm Surge assessment, Floods- Fluvial and Pluvial flooding, Forest Fire, Case studies on Man Made disasters, Mitigation and Management of field works related to disaster management.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon successful completion of the course, students will be able to

CO1: Differentiate the types of disasters and its causes
CO2: Describe the impacts of disaster on environment and society
CO3: Discuss the strengths and weaknesses of disaster management approaches
CO4: Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
CO5: Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.

TEXTBOOKS

1. Singhal JP, Disaster management, Laxmi publications, 2010. ISBN -10: 9380386427, ISBN-13: 978- 9380386423.
2. Tushar Bhattacharya, Disaster science and Management, McGraw Hill India Education Pvt Ltd., 2012. ISBN-10 1259007367, ISBN-13: 978-1259007361.
3. Gupta Anil K, Sreeja S. Nair. Environmental Knowledge for disaster risk management, NIDM, New Delhi, 2011
4. Kapur Anu Vulnerable India: A Geographical study of Disasters, IIAS and Sage Publishers, New Delhi, 2010.

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep &
2. Deep Publication Pvt. Ltd., New Delhi,2009.
3. NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies

"'NewRoyal book Company, 2007.
4. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi, 2001.

ONLINE RESOURCES

1. https://nptel.ac.in/courses/105/104/105104183/
2. https://www.coursera.org/learn/disaster-preparedness

CO-PO/PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	2			2					1	3		2
CO2	3	2	3	2			2					1	3		2
CO3	3	2	3	2			2					1	3		2
CO4	3	2	3	2			2					1	3		2
CO5	3	2	3	2			2					1	3		2

Mapping of courses – M. Tech I.T

Subject Name	**Sustainable Development Goals**																
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Advanced Artificial Intelligence								✓	✓		✓						
Blockchain Technology									✓		✓						
Mobile Application Development									✓		✓						
Robotic Programming				✓					✓		✓			✓	✓		
Health, Sports and Financial Analytics			✓	✓		✓	✓	✓									

COURSE CODE	COURSE TITLE	L	T	P	C
PIF2102	**ADVANCED ARTIFICIAL INTELLIGENCE**	3	0	0	3

OBJECTIVES

- To understand the role of logic in artificial intelligence
- To understand knowledge and reasoning under certainty and uncertainty
- To enable design and implement AI principles for problem solving, inference and perception
- To implement algorithms on simple and complex decision making

UNIT I KNOWLEDGE AND REASONING 9

Propositional Logic: Simple logic – Propositional theorem proving – Effective propositional model checking – Agents based on propositional logic – First order logic – Representation – syntax and semantics – using first order logic – knowledge engineering in first order logic; Propositional vs first order inference - Unification and lifting – forward and backward chaining – resolution.

UNIT II PLANNING AND REPRESENTATION 9

Classical planning: definition – algorithms for planning as state space search – planning graphs – classical planning approaches – analysis; Knowledge representation: Ontological engineering -

categories and objects - events – mental events and mental objects – reasoning systems for categories – reasoning with default information – Case study: The internet shopping world.

UNIT III UNCERTAIN KNOWLEDGE 9

Uncertainty - Quantifying uncertainty - Acting under uncertainty – basic probability notation – inference using full joint distributions – independence - Bayes' rule and its use

UNIT IV PROBABILISTIC REASONING 9

Representing knowledge in an uncertain domain – semantics of Bayesian networks – efficient representation of conditional distributions – exact and approximate inference in Bayesian networks - relational and first order probability models – Time and uncertainty – inference in temporal models- Bayesian Learning: Learning with complete and hidden data – Expectation Maximization Algorithm; – Hidden Markov Models – Kalman filters – dynamic Bayesian networks – multiple object tracking.

UNIT V DECISION MAKING AND LEARNING 9

Reinforcement Learning : Basics of Reinforcement learning – Active and Passive reinforcement learning – Generalization – Applications ;Making simple decisions: combining beliefs and desires – The basis of utility theory – Utility functions – multi attribute utility functions – decision networks – The value of information – Decision theoretic expert systems; Sequential Decision problems – value iteration – policy iteration – Partially Observable MDPs ; Decisions with Multiple Agents : Game Theory – Mechanism Design.

Case Studies that map sustainable development goals 3,4,6,7,9,11,13,14,15 (3: Good health and well being, 4: Quality education, 6: Clean water and sanitation, 7: Affordable and clean energy, 9: Industry, innovation and infrastructure, 11: Sustainable cities and communities, 13: Climate action, 14: Life below water, 15: Life on land)

TOTAL PERIODS: 45

TEXT BOOK

1. Artificial Intelligence: A modern approach, by Stuart Russell and Peter Norvig, Third Edition, Pearson Series in Artificial Intelligence. 2020.

REFERENCES

1. Artificial Intelligence Engines: A Tutorial Introduction to the Mathematics of Deep Learning by James V Stone, Sebtel Press, 2019.
2. Artificial Intelligence by Example: Acquire advanced AI, machine learning, and deep learning design skills by Denis Rothman, 2nd Edition, 2020.
3. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006
4. Ethem Alpaydin, Introduction to Machine Learning, MIT Press, Prentice Hall of India, Third Edition 2014.

COURSE OUTCOMES

At the end of the course, the students should be able to

CO 1: Identify the role of propositional and first order logic in Artificial Intelligence
CO 2: Demonstrate an understanding of knowledge and reasoning under certainty and uncertainty.
CO 3: Apply principles of AI in solutions that require problem solving, inference, perception CO 4: Implement algorithms on simple and complex decision making.

COs	POs			PSOs		
	1	2	3	1	2	3
1	1		1			
2	2	2	1	1	1	1
3	1		1	1	1	1
4			1			1

COURSE CODE	COURSE TITLE	L	T	P	C
PIF2222	BLOCKCHAIN TECHNOLOGY	2	0	2	3

OBJECTIVES

- To learn the fundamentals of Blockchain.
- To obtain knowledge about technologies of Blockchain.
- To understand the different models used in Blockchain.
- To learn solidity programming to understand Ethereum based blockchain.
- To learn to code Hyperledger Fabric to establish enterprise based blockchain.

UNIT I INTRODUCTION **6**

Basic Cryptographic primitives used in Blockchain –Secure- Collision Resistant hash functions - Digital signature – Public-key cryptosystems - Zero-knowledge proof systems - Need for Distributed Record-Keeping - Modelling faults and adversaries- Byzantine Generals problem - Consensus algorithms and their scalability problems.

UNIT II TECHNOLOGIES BORROWED IN BLOCKCHAIN **6**

Technologies Borrowed in Blockchain –hash pointers- Consensus- Byzantine Models of fault tolerance- Digital cash etc.- Bitcoin blockchain - Wallet - Blocks - Merkley Tree - hardness of mining
- Transaction verifiability - Anonymity - forks - Double spending.

UNIT III MODELS FOR BLOCKCHAIN **6**

Models f-GARAY model -RLA Model -Proof of Work (PoW) as a random oracle - Formal treatment of consistency- Liveness and Fairness - Proof of Stake (PoS) based Chains -Hybrid models (PoW + PoS)

UNIT IV ETHEREUM **6**

Ethereum -Ethereum Virtual Machine (EVM) -Wallets for Ethereum -Solidity - Smart Contracts - The Turing Completeness of Smart Contract Languages and verification challenges

UNIT V HYPERLEDGER FABRIC **6**

Hyperledger fabric- the plug and play platform and mechanisms in permissioned blockchain - applications of blockchain in cyber security- integrity of information- E-Governance and other contract enforcement mechanisms - Limitations of blockchain as technology and myths vs reality of blockchain technology
Case studies that map sustainable development goals such as 9, 11 (9: Industry, innovation and infrastructure, 11: Sustainable cities and communities)

TOTAL LECTURE PERIODS: 30

LAB COMPONENT **TOTAL LAB**

PERIODS: 30 LIST OF EXPERIMENTS

List of Experiments using Solidity

Environmen
t setup Basic
syntax
First and sample application
Comments
Types, Variables and Variable
scope Operators
Loops and Decision making
Strings, Arrays and Enum
Structs, Mappings and
Conversions Ether units and
special variables Mini project

List of Experiments using Hyperledger Fabric

Introduction
Hyperledger Fabric Model
How Fabric networks are
structured Identity
Membership Service Provider (MSP)
Policies
Peers Ledger
The Ordering Service
Smart Contracts and
Chaincode Fabric chaincode
lifecyclePrivate data Channel
capabilities Security Model
Use Cases

TEXTBOOKS

1. S.Shukla, M.Dhawan, S.Sharma, S. Venkatesan "Blockchain Technology: Cryptocurrency and Applications, Oxford University Press 2019.
2. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller and Steven Goldfeder, " Bitcoin and cryptocurrency technologies: a comprehensive introduction", Princeton University Press,2016.

REFERENCES

1. Joseph Bonneau et al, SoK: "Research perspectives and challenges for Bitcoin and cryptocurrency", IEEE Symposium on Security and Privacy, 2015
2. J.A.Garay et al, "The bitcoin backbone protocol - analysis and applications", EUROCRYPT 2015, Volume 2.
3. R.Pass et al, "Analysis of Blockchain protocol in Asynchronous networks", EUROCRYPT 2017.

4. Pass et al," Fruitchain- a fair blockchain", PODC 2017

OUTCOMES

At the end of the course, the student should be able to

CO1: Explain the fundamentals of Blockchain
CO2: Illustrate the technologies used to build
Blockchain CO3: Describe the models of
Blockchain
CO4: Apply the solidity language to develop smart contracts
CO5: Demonstrate Hyperledger fabric for the enterprise applications

COs	POs			PSOs		
	1	**2**	**3**	**1**	**2**	**3**
1	1		1	2		3
2	1		1	2		3
3	1		1	2		3
4	1	3	3	3	3	3
5	1	3	3	3	3	3

COURSE CODE	COURSE TITLE	L	T	P	C
PIF2228	**MOBILE APPLICATION DEVELOPMENT**	**1**	**0**	**4**	**3**

OBJECTIVES

- To learn how to use Flutter to rapidly develop a mobile app that runs on both iOS and Android devices.
- To understand the use of Flutter, including building a UI, using animations, and creating a database app.
- To explore state management and asynchronous programming in Dart &Flutter.
- To gain knowledge on how to use Flutter with Firebase.

UNIT I: GETTING STARTED WITH FLUTTER **3**

Introducing Flutter – Widget Lifecycle Events – Widget Tree and Element Tree – Dart Basics
Lab Component: Installing the Flutter SDK – Configuring the Android Studio Editor – Creating a Hello World App – Creating a Starter Project Template.

UNIT II: FLUTTER USER INTERACTION, STYLES, AND ANIMATIONS **3**

Flutter UI – User Interaction and gestures – Flutter forms – Flutter Animations
Lab Component: Adding Animation to an App - Creating an App's Navigation – Creating Scrolling Lists and Effects – Building Layouts – Applying Interactivity – Writing Platform-Native Code.

UNIT III: STATE MANAGEMENT **3**

Routing in Flutter – Declarative routing and named routes – Routing animations – Flutter State Management.
Lab Component: Building a 2D game with Flutter state management

UNIT IV: ASYNCHRONOUS DART **3**
Business Logic Components - Async Dart – Sinks and streams – Using streams in blocs – Async Flutter.
Lab Component: Build interactive live streams using Async Dart with Flutter.

UNIT V: BEYOND FOUNDATIONS **3**
HTTP and Flutter – JSON Serialization – Working with Firebase in Flutter – Dependency Injection in the App - Kotlin Foundations – Simple APP Design.
Lab Component: Mini-project using Firebase Cloud Firestore and Flutter

Projects that map sustainable development goals such as 9, 11 (9: Industry, innovation and infrastructure, 11: Sustainable cities and communities)

TOTAL LECTURE PERIODS: 15

LAB COMPONENT **TOTAL PERIODS: 60**

TEXT BOOKS

1. Eric Windmill, "Flutter in Action", Manning Publications; 1st Edition, 2019.
2. Marco L. Napoli, "Beginning Flutter: A Hands On Guide to App Development", Wrox, 1st Edition, 2019.

REFERENCES:

1. Alberto Miola, Felix Angelov, Matej Rešetár, Rémi Rousselet, "Flutter Complete Reference: Create beautiful, fast and native apps for any device", Kindle Edition, 2020.
2. Simone Alessandria, Brian Kayfitz, "Flutter Cookbook: Over 100 proven techniques and solutions for app development with Flutter 2.2 and Dart", 1st Edition, Kindle Edition, 2021.
3. Barry Burd, "Flutter For Dummies", 1st Edition, Kindle Edition, 2020.
4. Simone Alessandria, Flutter Projects: A practical project-based guide to building real-world cross-platform mobile applications and games, publisher: packt publishing, www.packt.com.
5. Carmine Zaccagnino, Programming Flutter: Native, Cross-Platform Apps the Easy Way (The Pragmatic Programmers), publisher: packt publishing, www.packt.com.
6. John Horton, Android Programming with Kotlin for Beginners: Build Android apps

starting from zero programming experience with the new Kotlin programming language Packt Publishing Limited, 2019.

WEB REFERENCES:

- https://aws.amazon.com/mobile/mobile-application-development/
- https://flutter.dev/(Applications)
- http://ai2.appinventor.mit.edu/ (Applications)
- https://developer.android.com/guide
- https://en.wikipedia.org/wiki/Android_10

OUTCOMES
At the end of the course, the students should be able to

CO1: Demonstrate how to use Flutter for creating cross-platform mobile apps, including how to setup the SDK and simulators; add widgets, components, and navigation.
CO2: Customize the app using sophisticated user interfaces, styles, and animations.
CO3: Apply state management techniques and asynchronous programming in Dart & Flutter. CO4: Build Firebase's real-time database in a Flutter App.

COs	POs			PSOs		
	1	**2**	**3**	**1**	**2**	**3**
1	2		1	3		
2	2		3	2		
3	2		3	2		
4	3	3	3	3	3	3

COURSE CODE	COURSE TITLE	L	T	P	C
PIF2325	**HEALTH, SPORTS, AND FINANCIAL ANALYTICS**	**3**	**0**	**0**	**3**

OBJECTIVES:

- To explore the various forms of electronic health care information.
- To learn the techniques adopted to analyze healthcare data.
- To understand the predictive models for clinical and sports data
- To understand the importance of sports & financial analytics.
- To use analytics, improvise financial situations.

UNIT I HEALTHCARE ANALYTICS I **9**

Introduction to Healthcare Data Analytics- Electronic Health Records– Components of EHR- Coding Systems- Benefits of EHR- Barrier to Adopting HER Challenges- Phenotyping Algorithms- Health Informatics on FHIR.

UNIT II HEALTHCARE ANALYTICS II **9**

Natural Language Processing and Data Mining for Clinical Text- Mining the Biomedical-Visual Analytics for Healthcare - Social Media Analytics for Healthcare - Case Study :COVID19 Pandemic Data.

UNIT III SPORTS ANALYTICS & APPLICATIONS 9

Understanding sports data - Creating performance metrics for players and teams - Forecasting and prediction - Machine learning in sports- Sports data visualization-Sports Analytics algorithms for performance prediction. Data Analytics Tools: Rating Sports Teams - The Ratings Percentage Index (RPI) - From Point Ratings to Probabilities - Ranking Great Sports Collapses – Case studies: Comparing Players from Different Eras

UNIT IV FINANCIAL DATA ANALYTICS & RISK MODELING 9

Definition, relevance and scope financial Analytics, Components of Financial Analytics, Features of Financial Analytics recent trends in financial analytics, building models using accounting and financial data. Measuring and modeling risk, Modeling Credit Risk.

UNIT V BUSINESS VALUATION ANALYTICS 9

Cash Flow statement – prepare and analyze, model and forecast financial statement & business valuation. Capital budgeting – application and issues

Case studies that map sustainable development goals such as 3, 6, 7, 8 (3: Good health and wellbeing, 6: Clean water and sanitation, 7: Affordable and clean energy, 8: Decent work and economic growth)

TOTAL PERIODS: 45

REFERENCES

1. Chandan K. Reddy and Charu C Aggarwal, “Healthcare data analytics”, Taylor & Francis, 2015.
2. FHIR - https://dl.acm.org/doi/book/10.5555/3281321
3. Massaad, Elie, and Patrick Cherfan. “Social Media Data Analytics on Telehealth During the COVID-19 Pandemic.” Cureus vol. 12,4 e7838. 26 Apr. 2020, doi:10.7759/cureus.7838
4. Wayne L. Winston, “Mathletics: How Gamblers, Managers, and Sports Enthusiasts Use Mathematics in Baseball, Basketball, and Football”, Pearson, 2012. (Part IV).
5. 5.https://www.mentionlytics.com/blog/social-media-monitoring-analytics-healthcare-systems
6. K. Apostolou and C. Tjortjis, "Sports Analytics algorithms for performance prediction," 2019 10th International Conference on Information, Intelligence,

Systems and Applications (IISA), 2019, pp. 1-4, doi: 10.1109/IISA.2019.8900754.
7. https://www.hindawi.com/journals/sp/2022/3547703/
8. Singh, Nitin. "Sport analytics: a review." learning 9 (2020): 11.
9. Dixon, Mathew F., Halperin, Igor, Bilokon, Paul, “Machine Learning in Finance”, O’Reilly, 2019

OUTCOMES:
On successful completion of the course the learner will be able to,

CO1: Apply analytics for decision making in healthcare services.
CO2: Apply data mining to develop efficient clinical decision support systems.
CO3: Recognize, formulate, and analyze decision-making in sports
CO4: Explain various concepts and applications of analytics in
Finance CO5: Use business value analytics in improving financial
outcomes.

COs	POs			PSOs		
	1	**2**	**3**	**1**	**2**	**3**
1	2	2	2	1		2
2	2	2	2	1		2
3	2	2	2	1		2
4	2	2	2	1		2
5	2	2	2	1		2

COURSE CODE	COURSE TITLE	L	T	P	C
PIF2323	**ROBOTIC PROGRAMMING**	**1**	**0**	**4**	**3**

COURSE OBJECTIVES

- To introduce the fundamental aspects of Robotics.
- To analyse trade-offs among position control, velocity control, and force control in simulation problem.
- To study the importance of Robotic Operating System
- To develop the programming skills related to kinematics, control, optimization.
- To have hands on interfacing the different sensors and actuators through ROS.

UNIT I FUNDAMENTALS OF ROBOTICS **3**

Robot - Definition - Robot Anatomy - Coordinate Systems, Robot Parts and their Functions- Need for Robots-Drives-Effectors-Sensors-Forward and Inverse Kinematics- Different Applications.

UNIT II SIMULATION OF PROGRAMMABLE ROBOTS **3**

Programming functions for perception vs reality of robots-Control functions for different desired behaviour-Differential drive functions for mobility in robot-API interface functions for sensors and actuators-Functions for regulating the velocity in robot

UNIT III ROBOT OPERATING SYSTEM **3**

Introduction to open-source meta operating system for robot-Working with ROS System-Programs for publishing and subscribing messages-Log messages. Graph resource names-Launch files- Parameters and Services. Installing ROS on an ARM based Board.

UNIT IV ROS ADVANCED CONCEPTS **3**

ROS file system-Understanding the Parameter server and Dynamic parameters-actionlib-Pluginlib- PCL Library-OpenGL Library-Selenium Library for Robot Framework--toolchains-nodelets- Gazebo Framework and Plugin-ROS transform frames-ROS visualization and Debugging Tools.

UNIT V INTERFACING SENSORS AND ACTUATORS THROUGH ROS **3**

Arduino-ROS Interface-Interfacing 9DoF Razor IMU with Arduino-ROS-Interfacing a GPS system- Interfacing Servomotors-Interfacing with Laser Rangefinder-Kinect sensor to view objects in 3D- Collision Avoidance Algorithms for Navigation-Gazebo architecture and interface with ROS.

TOTAL LECTURE PERIODS: 15

LAB COMPONENT **TOTAL PERIODS: 60**

LIST OF EXPERIMENTS:

1. Study of different components used in robot.
2. Study of different functions used to perform different types of movement in robot.
3. Study of Robot Operating System.
4. Study of visualization in ROS.
5. Installing ROS in Arduino based board.
6. Program to access the different sensors and actuators through ROS.
7. Study of Navigation stack in ROS.
8. Implementation of localization using Navigation stack in ROS.
9. Program to perform visualization.
10. Program to control the robots in simulation.

11. Study of Mobile Autonomous robot.

12. Program to implement collision avoidance

Projects that map to sustainable development goals such as 9, 11, 14, 15 (9: Industry, innovation and infrastructure, 11: Sustainable cities and communities, 14: Life below water, 15: Life on land)

TEXTBOOKS:

1. Programming Robots with Robotic Operating System-A practical introduction to the Robot Operating System, Morgan Quigley, Brian Gerkey & William D. Smart, O'REILLY.
2. Robot Operating Systems for Absolute Beginers- Robotic Programming made easy, Lentin Joseph, Apress,
3. ROS Robot Operating System From the basic concepts to Practical Programming and Robot Applications, YoonSeokPyo, HanCheol Cho, RyuWoon Jung &TaeHoon Lim
4. Robot Operating System - The Complete Reference (Volume 4) ,Janusz Kacprzyk, Polish Academy of Sciences, Warsaw, Poland, Springer

REFERENCES:

1. Robot Operating System(ROS) The complete Reference(Volume 1) , Anis Kouba, Springer, Artificial Intelligence Studies.
2. Robot Operating System(ROS) The complete Reference(Volume 2) , Anis Kouba, Springer, Artificial Intelligence Studies.
3. Robot Operating System(ROS) The complete Reference(Volume 3) , Anis Kouba, Springer, Artificial Intelligence Studies

OUTCOMES:

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

CO1: Perform hands-on introduction to the many engineering principles involved for Robotics.
CO2: Design systems with various flexures, actuators and sensor systems for Robots
CO3: Implement various control function for mobility of Robot.
CO4: Analyze the manipulation and navigation problems using knowledge of coordinate frames, kinematics, optimization, control, and uncertainty.

COs	**POs**			**PSOs**		
	1	**2**	**3**	**1**	**2**	**3**
1	3	1	2	1	3	3
2	3	1	2	1	3	3
3	3	1	2	1	3	3

4	3	1	2	1	3	3

Mapping of courses – M.E. Energy Engineering

Course	**Sustainable Development Goals**																
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Renewable Energy Systems							✓	✓	✓		✓			✓	✓		✓
Advanced Power Plant Engineering							✓	✓	✓								
Energy conservation in industrial utilities							✓	✓	✓		✓	✓					
Solar Energy Technologies							✓	✓	✓		✓				✓		
Wind Energy Technologies							✓	✓	✓		✓				✓		
Bio Energy Conversion Techniques							✓	✓	✓		✓				✓		
Electric and Hybrid Electric Vehicles							✓	✓	✓		✓		✓		✓		✓
Hydrogen and Fuel Cell Technologies							✓	✓	✓			✓			✓		
Energy Conservation in Electrical Systems							✓	✓	✓		✓	✓					
Energy Efficient Buildings							✓	✓	✓		✓	✓			✓		✓
Advanced Energy Storage Technologies							✓	✓	✓		✓						
Energy Forecasting, Modeling and Project Management							✓	✓	✓								
Environmental Engineering and Pollution Control			✓			✓	✓		✓		✓					✓	
Waste Management and Energy Recovery							✓		✓		✓						
Nanomaterials for Energy and Environment			✓				✓		✓			✓					

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**

PEY2103	RENEWABLE ENERGY SYSTEMS	3	0	0	3

OBJECTIVES:

The objective of the course is to introduce students about different new and renewable energy sources and systems highlighting the present renewable energy status of our country.

UNIT I SOLAR ENERGY 9

General introduction to renewable and non-renewable sources of energy, present national scenario, Solar power-solar radiation and its measurement, solar thermal systems - flat plate collectors, evacuated tube collectors, solar concentrators, solar thermal applications – drying, cooking and refrigeration, solar photovoltaics (PV), types of solar cells, I-V characteristics, efficiency, solar tracking, PV applications – lighting, pumping and power generation.

UNIT II WIND ENERGY 9

Basics of wind energy conversion, types of wind turbines – horizontal and vertical axis, components, working, performance, Betz limit, site selection of wind power plants - resource assessment, wind farms, hybrid systems, safety and environmental aspects, grid integration and issues, present national wind power scenario.

UNIT III BIO-ENERGY 9

Biomass resources, classifications, biomass conversion – thermochemical conversion, direct combustion, gasification, liquefaction – biochemical conversion – aerobic and anaerobic digestion - Biogas Production - Types of Biogas Plants – applications

UNIT IV HYDROGEN AND FUEL CELLS 9

Hydrogen energy - production techniques – storage – safety – applications, fuel cell – fundamentals - types – working – applications – advantages and drawbacks – batteries – types – working – applications – comparison with fuel cells.

UNIT V OTHER RENEWABLE ENERGY SYSTEMS 9

Geothermal energy, Hydel energy, Tidal energy, Wave energy, Ocean Thermal Energy Conversion systems (OTEC), site selection, layout and components.

TOTAL PERIODS: 45

COURSE OUTCOMES

After completing the course, students will be able to

CO#	Course Outcomes	Knowledge Level
CO1	understand the concepts of solar energy.	K2:U
CO2	understand the concepts of wind energy.	K2:U
CO3	understand the concepts of biomass and biogas energy.	K2:U

CO4	understand the production, storage of hydrogen energy and its applications in different fuel cells.	K2:U
CO5	understand the concepts of geothermal and hydel energy.	K2:U

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1			3	1	3	
CO2			3	1	3	
CO3			3	1	3	
CO4		1	3	1	3	
CO5		1	3	1	3	

REFERENCE BOOKS

1. Archie W.Culp, Principles of Energy Conversion, McGraw-Hill Inc., Singapore, 1991.
2. Barclay F.J., Fuel Cells, Engines and Hydrogen, Wiley, 2009.
3. Hart A.B. and Womack G.J., Fuel Cells: Theory and Application, Prentice Hall,Newyork Ltd., London 1989.
4. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications,John Wiley & Sons2002.
5. Kettari M.A., Direct Energy Conversion, Addison-Wesley Pub. Co1997.
6. Kordesch K. and Simader G., Fuel Cell and Their Applications, Wiley, Germany1996.

COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
PEY2104	**ADVANCED POWER PLANT ENGINEERING**	**PE**	**3**	**0**	**0**	**3**

OBJECTIVES:

The objectives of the course are to introduce students about India's energy scenario and environmental issues associated with power plants, learn about conventional and advancedpower plant cycles, Cogeneration systems and so on.

UNIT I INTRODUCTION **9**

Overview of Indian power sector, current scenario of coal based thermal power plants and fossil fuels – coal, oil and natural gas - power plants-load curves for various applications, load factor, demand factors, plant utilization factors, traditional power plants-merits and demerits, selection of power plants, economics of power plants.

UNIT II STEAM POWER PLANTS **9**

Layout of steam power plant, selection criteria for steam power plants, merits and demerits, types of coal, ash and ash utilization, modern high pressure steam boilers, Rankine cycle, superheat, reheat and regeneration, instrumentation in steam power plants.

UNIT III HYDROELECTRIC AND NUCLEAR POWER PLANTS 9

Hydroelectric Power plants, hydel Scenario of India, selection criteria, hydel power plant layout, small hydel power plants (SHPs), merits and demerits. Nuclear power and fundamentals, chain reactions, nuclear fuels, components, of nuclear power plants, nuclear reactors and types – PWR, BWR, CANDU, Gas Cooled, Liquid Metal Cooled and Breeder reactor - nuclear safety – nuclear waste disposal, environmental issues.

UNIT IV DIESEL AND GAS TURBINE POWER PLANTS 9

Diesel cycle, layout of diesel cycle power plant, components, merits and Brayton cycle, components of a gas turbine power plant, merits and demerits of gas turbine plants, intercooling, reheat and regenerative gas turbine cycles, advantages and limitations.

UNIT V ADVANCED POWER CYCLES AND PLANTS 9

Combined heat and power (CHP), Cogeneration systems – topping & bottoming cycles, heat to power ratio, organic Rankine cycles (ORC), combined cycle power plants - steam and gas turbine plants, ocean thermal power plants, solar power plants, wind power plants, hybrid power plants - thermal-solar, hydel-solar and solar-wind power plants, geothermal power plants, magneto hydrodynamic (MHD) power plants.

TOTAL PERIODS 45

COURSE OUTCOMES

On successful completion of this course, the student will be able to

CO#	Course Outcomes	Knowledge Level
CO1	understand in general about Indian power sectors, various power plants and understand how the load factor of power plants are arrived at.	K2:U
CO2	understand the basic operations of steam power plants and main components such as boilers, nozzles, cooling towers etc.	K2:U
CO3	understand the basics operation of Diesel and Gas Turbine power plants.	K2:U
CO4	understand the layout and operation of hydel and nuclear power plants.	K2:U
CO5	understand about cogeneration systems and advanced power cycles like MHD & Hybrid power plants.	K2:U

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1			3	1	3	
CO2			3	1	3	
CO3			3	1	3	
CO4		1	3	1	3	
CO5		1	3	1	3	

REFERENCE BOOKS

1. Arora and Domkundwar, A course in power Plant Engineering, Dhanpat Rai and CO, 2004.

2. Rajput R.K., A Textbook of Power Plant Engineering, Laxmi Publications, 5th Edition,2016.
3. Nag P.K., Power Plant Engineering, Tata Mcgraw Hill Publishing Co Ltd, New Delhi,1998.
4. Gill A.B., Power Plant Performance, Butterworths, 1984.
5. Haywood R.W., Analysis of Engineering Cycles, 4th Edition, Pergamon Press, Oxford,1991.
6. Horlock J.H., Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford,1987.
7. Lamarsh J.R., Introduction to Nuclear Engineering - 2nd edition, Addison-Wesley, 1983.

COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
PEY2201	ENERGY CONSERVATION IN INDUSTRIAL UTILITIES	PC	3	0	0	3

OBJECTIVES:

The objective of the course is to introduce students about India's energy scenario, BEE, EC Act,and familiarize on energy audit, energy management, industrial and domestic thermal utilities.

UNIT I INTRODUCTION **9**

Indian Energy Scenario – Basics of Energy and its various forms - Primary / Secondary Energy Sources – Energy Conservation – Energy Intensive Industries – Barriers – Energy Conservation Act (EC Act) - 2001: Salient Features – Amendment to EC Act 2001 - Schemes of Bureau of Energy Efficiency (BEE) including Designated consumers, State Designated Agencies - Integrated energy policy - National action plan on climate change.

UNIT II ENERGY AUDIT **9**

Definition of energy audit, need, types of energy audits, detailed methodology, energy audit report, energy audit instruments and metering, smart metering and sample case studies on energyaudits.

UNIT III ENERGY MANAGEMENT **9**

Energy management, objectives, managerial functions, implementation of energy management, role of energy auditors, energy managers, Energy Management Systems – Aspects of ISO 50001:2018, ENCON scheme, bench marking, Cost / Energy Share Diagram – Break Even Analysis — Financial Analysis Techniques – CUSUM Technique – Energy Management Information Systems (EMIS) ESCO Concept – ESCO Contracts.

UNIT IV THERMAL UTILITIES **9**

Industrial boilers, furnaces, fuels and types, industrial thermal insulation, types, heat exchangers, cooling towers, Waste Heat Recovery and Cogeneration Systems, Basics of HVAC systems, EER, Energy conservation opportunities in HVAC, BEE Star ratings.

UNIT V ELECTRICAL UTILITIES **9**

Power Factor- basics - automatic power factor controllers, Soft starters with energy saver - electronic ballast, Electric motor types - losses in induction motors - motor efficiency, energy conservation opportunities in fans, compressors, blowers and pumps – Variable Frequency Drives (VFD) - energy conservation in lighting systems, New generation luminaries - Light Emitting Diodes (LEDs).

TOTAL PERIODS 45

COURSE OUTCOMES

On successful completion of this course, the student will be able to

CO#	Course Outcomes	Knowledge Level
CO1	understand India's energy scenario, act as per the guideline of EC Act 2001 & amendments and understanding the roles of BEE on energy conservation.	K2:U
CO2	carryout energy audits as a beginner applying the methodology involved.	K3: Ap
CO3	Understand the key roles of energy managers/energy auditors/EMIS, solve problems applying CUSUM techniques and perform problems related to Break Even Analysis.	K2:U
CO4	apply the fundamental concepts of industrial furnaces and thermal systems such as heat exchangers, waste heat recovery systems, energy storage, etc. in real situations.	K3: Ap
CO5	apply the fundamental knowledge gained on HVAC systems for advance level courses or designs of systems such as heat pumps, refrigerators and air conditioners.	K3: Ap

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	1		3	1	3	
CO2	1	1	3	1	3	
CO3	1	1	3	1	3	
CO4	1		3	1	3	
CO5	1		3	1	3	

REFERENCE BOOKS

1. Chakrabarti, Amlan, Energy Engineering and Management, PHI Learning Pvt. Ltd., 2018
2. Gupta O.P., Elements of Fuels, Furnaces and Refractories, Khanna Publishers, 1997.
3. Horlock J.H., Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford,1987.
4. Arora C.P., Refrigeration and Airconditioning, Tata McGraw Hill, 2009, 3rd ed.
5. Hamies, Energy Auditing and Conservation; Methods Measurements, Management andCase study, Hemisphere, Washington, 1980.
6. Handbook on Energy Efficiency, TERI, New Delhi, 2001.
7. Smith C.B., Energy Management Principles, Pergamon Press, New York, 1981.
8. Trivedi P.R., Jolka K.R., Energy Management, Commonwealth Publication, New Delhi,1997.

9. Write Larry C., Industrial Energy Management and Utilization, Hemisphere Publishers,Washington, 1988.
10. Guide book for National Certification Examination for Energy Managers and EnergyAuditors (Could be downloaded from www.energymanagertraining.com.

TOTAL PERIODS: 30

COURSE OUTCOMES

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

CO#	Course Outcomes	Knowledge Level
CO1	Identify a real time industrial problem, apply fundamental knowledge to solve the problem	K3:Ap
CO2	Analyze the solution(s) and present/communicate the solution(s) and file as a report	K4:An

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	3	2	3	3
CO2	3	3	3	2	3	3

COURSE CODE	COURSE TITLE	L	T	P	C
PEY2221	SOLAR ENERGY TECHNOLOGIES	3	0	0	3

OBJECTIVES:

The objective of the course is to develop an understanding about solar radiation, solar thermal/PV technologies, and passive solar architecture.

UNIT I SOLAR RADIATION AND ESTIMATION 9

Solar energy scenario. Laws of radiation-problems, Components of solar radiation, extra-terrestrial radiation, Solar angles -sunrise and sunset time -average global radiation-problems. Sun path diagrams. Solar radiation measurement-global, direct and diffuse solar radiations- pyroheliometer, pyranometer, pyrgeometer, sunshine recorder – an overview of solar radiation data in India.

UNIT II SOLAR THERMAL SYSTEMS 12

Solar thermal-basics-Flat plate collectors – components-absorber coating-Glazing-thermal analysis-performance parameters-Evacuated tubular collectors- f-chart method for active heating systems, Concentrating solar collectors – classification – Construction and basic parameters of compound parabolic concentrators – parabolic trough concentrators - concentrators with point focus – Heliostats, Solar tracking systems. Applications: Solar heating systems - natural and forced, solar cooling systems - Absorption and PV based systems, solar desalination systems, solar cookers, solar ponds, solar dryers.

UNIT III SOLAR PV FUNDAMENTALS 9

Semiconductors-doping – charge carriers. P-N Junction, homo- hetero- junctions, metal-semiconductor interface - dark and illumination characteristics – characteristics of solar cell - efficiency limits - variation of efficiency with bandgap and temperature -losses in solar cell- efficiency measurements. High efficiency cells-rear point contact-buried contact-PERL. Solar thermo-photovoltaics.

UNIT IV SOLAR PV SYSTEMS 9

Solar photovoltaic cell-module-panel-array, power output-series and parallel connections, Designing PV system for a given load, shadow analysis, maximum power point tracking. Storage autonomy -simple problems, parameters used to assess the performance of batteries. Centralized and decentralized SPV (solar photovoltaic) systems - standalone - hybrid and grid connected systems, Concepts- Balance of systems and Life cycle cost.

UNIT V PASSIVE ARCHITECTURE 6

Thermal comfort - bioclimatic classification, fabric heat gain in built structures, passive heating concepts: direct heat gain - indirect heat gain, solar window, concept of sol-air temperature Passive cooling concepts: Radiative cooling - shading - paints and cavity walls for cooling - roof radiation traps.

TOTAL PERIODS: 45

COURSE OUTCOMES

After completing the course, students will be able to

CO#	Course Outcomes	Knowledge Level
CO1	Estimate solar angles and compare various types of solar collectors	K4:An
CO2	Design a simple solar thermal based system	K4:An
CO3	Explain the characteristics of photovoltaic cell	K4:An
CO4	Design simple solar PV systems for domestic and industrial application	K4:An
CO5	Explain passive solar concepts to create thermal comfort	K4:An

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1			3		3	
CO2			3		3	
CO3			3		3	
CO4		1	3		3	
CO5		1	3		3	

REFERENCE BOOKS

1. Goswami D.Y., Kreider, J.F. and Francis, Principles of Solar Engineering, Taylor and Francis, 2000.
2. Chetan Singh Solanki, Solar Photovoltaics–Fundamentals, Technologies and Applications, PHI Learning Private limited, 2011.

3. Sukhatme S.P., Nayak. J.P, Solar Energy – Principle of Thermal collection and storage, Tata McGraw Hill, Fourth edition, 2017.
4. Arora C.P, Refrigeration and Airconditioning, Tata McGraw-Hill Publishing Company Ltd., 2000.
5. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, second edition, John Wiley, New York, 1991
6. The physics of solar cells, J. Nelson, Imperial college press, 2006.
7. Klaus Jager, Olindo Isabella, Arno Smets, René van Swaaij, Miro Zeman, Solar energy: fundamentals, technology, and systems, UIT Cambridge, 2016
8. R.K.Aggarwal, Solar Passive Architecture Techniques: Concept, design, calculation and performance evaluation, LAP Lambert Academic Publishing, 2011.

COURSE CODE	COURSE TITLE	L	T	P	C
PEY2222	WIND ENERGY TECHNOLOGIES	3	0	0	3

OBJECTIVE:

The objective of the course is to make students learn the essentials of wind energy systems, aerodynamics and functional aspects of wind turbine components in detail.

UNIT I WIND ENERGY FUNDAMENTALS & WIND MEASUREMENTS 9

Wind Energy Basics, Wind Speeds and scales, Terrain, Roughness, Wind Mechanics, Power Content, Class of wind turbines, Atmospheric Boundary Layers, Turbulence. Instrumentation for wind measurements, Wind data analysis, tabulation, Wind resource estimation, Betz's Limit, Turbulence Analysis. Present scenario of wind power generation.

UNIT II AERODYNAMICS THEORY & WIND TURBINE TYPES 9

Airfoil terminology, Blade element theory, Blade design, Rotor performance and dynamics, Balancing technique (Rotor & Blade), Types of loads; Sources of loads Vertical Axis Type, Horizontal Axis, Constant Speed Constant Frequency, Variable speed Variable Frequency, UpWind, Down Wind, Stall Control, Pitch Control, Gear Coupled Generator type, Direct Generator Drive /PMG/Rotor Excited Sync Generator.

UNIT III GEAR COUPLED GENERATOR WIND TURBINE COMPONENTS ANDTHEIR CONSTRUCTION 9

Electronics Sensors/Encoder/Resolvers, Wind Measurement : Anemometer & Wind Vane, Grid Synchronization System, Soft Starter, Switchgear [ACB/VCB], Transformer, Cables and assembly, Compensation Panel, Programmable Logic Control, UPS, Yaw & Pitch System : AC Drives, Safety Chain Circuits, Generator Rotor Resistor controller (Flexi Slip), Differential Protection Relay for Generator, Battery/Super Capacitor Charger & Batteries/ Super Capacitor for Pitch System, Transient Suppressor/Lightning Arrestors, Oscillation & Vibration sensing.

UNIT IV DIRECT ROTOR COUPLED GENERATOR (MULTIPOLE)

[VARIABLESPEED VARIABLE FREQUENCY] 9

Excited Rotor Synch, Generator/PMG Generator, Control Rectifier, Capacitor Banks, Step Up/Boost Converter (DC-DC Step Up), Grid Tied Inverter, Power Management, Grid Monitoring UNIT (Voltage and Current), Transformer, Safety Chain Circuits.

UNIT V MODERN WIND TURBINE CONTROL & MONITORING SYSTEM 9

Details of Pitch System & Control Algorithms, Protections used & Safety Consideration in Wind turbines, Wind Turbine Monitoring with Error codes, SCADA & Databases: Remote Monitoring and Generation Reports, Operation & Maintenance for Product Life Cycle, Balancing technique (Rotor & Blade), FACTS control & LVRT & New trends for new GridCodes.

TOTAL PERIODS: 45

COURSE OUTCOMES

After completion of the course, students will be able to

CO#	Course Outcomes	Knowledge Level
CO1	Identify different wind turbine components and enumerate its functions.	K2:U
CO2	Know the basic aerodynamic principles of wind energy systems.	K2:U
CO3	Know the functioning and construction of different wind turbine electrical components.	K2:U
CO4	Know about the power generation and management of wind turbines.	K2:U
CO5	Enumerate the functioning of modern wind turbines and control mechanisms involved.	K2:U

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1			3		3	
CO2			3		3	
CO3			3		3	
CO4		1	3		3	
CO5		1	3		3	

REFERENCE BOOKS

1. C-Wet : Wind Energy Resources Survey in India VI
2. Duffie A. and Beckman W.A., Solar Enginering of Thermal Processes, J Wiley, 1991
3. Freris L.L., Wind Energy Conversion Systems, Prentice Hall, 1990.
4. Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, Oxford UniversityPress, 1996.
5. John D Sorensen and Jens N Sorensen, Wind Energy Systems,Woodhead Publishing Ltd, 2011.
6. Mario Garcia –Sanz, Constantine H. Houpis, Wind Energy Systems, CRC Press2012.
7. Spera D.A., Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press, 1994.

COURSE CODE	COURSE TITLE	L	T	P	C
PEY2223	BIO ENERGY CONVERSION TECHNIQUES	3	0	0	3

OBJECTIVES:

The objective of the course is to introduce students about biomass, its production, combustion, gasification and biofuels.

UNIT I INTRODUCTION 7

Biomass: types – advantages and drawbacks – Indian scenario – characteristics – composition – Proximate & Ultimate Analysis - Thermogravimetric analysis – Differential Thermal Analysis – Differential Scanning Calorimetry – Different conversion approaches – thermal conversion, thermochemical conversion, and biochemical conversion.

UNIT II BIO CONVERSION OF BIOMASS 10

Biomass structure – Pretreatment of biomass – Biochemical conversion technologies: anaerobic digestion (biomethanation) and fermentation – Anaerobic digestion – pretreatment – parameters affecting gas production – effect of catalyst on biogas yield – Fermentation – Microbes for ethanol production – Enzymatic hydrolysis – Factors affecting enzymatic hydrolysis - Enzyme recycling, yield calculation.

UNIT III BIOMASS COMBUSTION 8

Perfect, complete and incomplete combustion – combustion properties of biomass – combustion stoichiometry – fixed Bed and fluid Bed combustion – fuel and ash handling systems – steam cost comparison with conventional fuels.

UNIT IV GASIFICATION, PYROLYSIS AND CARBONISATION 12

Chemistry of gasification - types – comparison – application – performance evaluation – economics – gas cooling and cleaning systems – Design of gasifier: fixed or moving bed, fluidized bed, and entrained flow - Pyrolysis - Classification - process governing parameters – Typical yield rates. Carbonization Techniques – merits of carbonized fuels - Use of gaseous fuels in IC - dual fuel mode.

UNIT V LIQUIFIED BIOFUELS

8

History of usage of Straight Vegetable Oil (SVO) as fuel - Biodiesel production from oil seeds, waste oils and algae - Process and chemistry – Use of Biodiesel in CI Engine - health effects / emissions / performance. Use of acholic fuels in Engine - CI and SI engine modifications.

TOTAL PERIODS: 45

COURSE OUTCOMES

After completion of this course, students will be able to

CO#	Course Outcomes	Knowledge

		Level
CO1	know about biomass as an energy source and current scenario of biomass in India	K2:U
CO2	familiarize on the methods of production and analysis of biogas obtained from biomass	K2:U
CO3	determine stoichiometric air requirements for combustion of biofuels using first principles	K3:Ap
CO4	know about gasification, pyrolysis and carbonization of biofuels	K2:U
CO5	evaluate the performance of liquid biofuels for IC engines and know about emission characteristics	K2:U

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1			3	1	3	
CO2			3	1	3	
CO3			3	1	3	
CO4		1	3	1	3	
CO5		1	3	2	3	

REFERENCE BOOKS

1. Robert C. Brown, Thermochemical Processing of Biomass, Conversion into Fuels, Chemicals and Power, 2019.
2. Pratima Bajpai, Biomass to Energy Conversion Technologies, The Road to Commercialization, 2020
3. Pravesh Chandra Shukla, Giacomo Belgiorno, Gabriele Di Blasio, Avinash Kumar Agarwal, Alcohol as an Alternative Fuel for Internal Combustion Engines, 2021
4. Abul Kalam Azad and Mohammad Rasul, Advanced Biofuels, Applications: Technologies and Environmental Sustainability, A volume in Woodhead Publishing Series in Energy, 2019
5. Best Practises Manual for Biomass Briquetting, I R E D A, 1997
6. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood Chichester, 1984.
7. Rai G.D., Non-conventional energy sources, Khanna publishes, 1993.
8. Tom B Reed, Biomass Gasification – Principles and Technology, Noyce Data Corporation, 1981.

COURSE CODE	COURSE TITLE	L	T	P	C
PEY2226	**ELECTRIC AND HYBRID ELECTRIC VEHICLES**	**3**	**0**	**0**	**3**

OBJECTIVES:

The objective of the course is to make students learn about the construction and working of Hybrid Electric Vehicles in detail. Another objective of the course is to impart the fundamental knowledge on batteries and alternative energy storage for hybrid electric

vehicles.

UNIT I INTRODUCTION TO EVs/HEVS **9**

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings, Comparisons of EV with internal combustion Engine vehicles, EV development in India, Fundamentals of vehicle mechanics-vehicle resistance-rolling resistance, aerodynamic drag, grading resistance.

UNIT II EV/HEV ARCHITECTURE AND POWERTRAIN **9**

Architecture of EV's and HEV's – Plug-in Hybrid Electric Vehicles (PHEV)-hybridization, series HEV, Parallel HEV, Series-Parallel HEV, powertrain components and sizing, regenerative braking.

UNIT III CONTROL OF DC AND AC DRIVES **9**

DC/DC chopper based four quadrant operations of DC drives – Inverter based V/f Operation (motoring and braking) of induction motor drive system – Induction motor and permanent motorbased vector control operation – Switched reluctance motor (SRM) drives.

UNIT IV ENERGY STORAGE FOR EVs/HEVs **9**

Battery energy storage, types of batteries, battery parameters, battery modeling, Traction Batteries, Lithium-ion batteries, mechanism, merits, challenges, battery thermal management systems, Ultracapacitors, flywheel energy storage and fuel cells.

UNIT V EV CHARGING AND ENERGY MANAGEMENT **9**

EV Charging - Classification of different charging technologies, introduction to Grid-to-Vehicle, Vehicle to Grid (V2G) or Vehicle to Buildings (V2B) or Vehicle to Home (V2H) charging operations, bi-directional EV charging systems, energy management strategies used in hybrid and electric vehicles, Wireless power transfer (WPT) technique for EV charging, battery swapping.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of this course, students will be able to

CO#	Course Outcomes	Knowledge Level
CO1	understand fundamentals of hybrid electric and electric vehicles.	K2:U
CO2	understand the architecture of electric vehicles.	K2:U
CO3	understand the function of controls for AC and DC drives	K2:U
CO4	understand the functioning of energy storage for EVs/HEVs	K2:U
CO5	understand EV charging techniques and energy management strategies	K2:U

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1			3	1	3	
CO2			3	1	3	
CO3			3	1	3	
CO4		1	3	1	3	
CO5		1	3	2	3	

REFERENCES

1. Iqbal Hussain, Electric and Hybrid Vehicles: Design Fundamentals, Second Edition, CRCPress, Taylor & Francis Group, Second Edition (2011).
2. Ali Emadi, Mehrdad Ehsani, John M. Miller, Vehicular Electric PowerSystems, Special Indian Edition, Marcel Dekker, Inc, 2010.
3. Chris Mi and M. Abul Masrur, Hybrid Electric Vehicles: Principles and Applications withPractical Perspectives, Wiley Publishers, 2011.
4. Tom Denton, Electric and Hybrid Vehicles, Institute of the Motor Industry,First Edition, Routledge Publishers, 2016.
5. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles (Fundamentals, Theory, and Design), CRC Press, 2005

COURSE CODE	COURSE TITLE	L	T	P	C
PEY2231	**HYDROGEN AND FUEL CELL TECHNOLOGIES**	**3**	**0**	**0**	**3**

OBJECTIVES:

The objective of the course is to enable students study in detail about hydrogen utility and fuel cell technology. Also, the course introduces about hydrogen production methodologies, its potential applications and storage options together with types of fuel cells, its thermodynamics and applications.

UNIT I HYDROGEN – BASICS AND PRODUCTION TECHNIQUES 9

Hydrogen – physical and chemical properties, salient characteristics. Production of hydrogen – steam reforming – water electrolysis – gasification and woody biomass conversion – biological hydrogen production – photo dissociation – direct thermal or catalytic splitting of water.

UNIT II HYDROGEN STORAGE AND APPLICATIONS 9

Hydrogen storage options – Compressed gas – Liquid hydrogen – Metal hydrides – Chemical storage, Hydrogen energy chain: Transport, Stationary power, Portable power and other applications, Environmental concerns and cost – Safety and management of hydrogen, Applications of Hydrogen

UNIT III FUEL CELLS – TYPES 9

History – principle – components – working – Types of fuel cells – Alkaline fuel cell, Phosphoric acid fuel cell, Solid oxide fuel cell, Molten carbonate fuel cell, Direct methanol fuel cell, Proton exchange membrane fuel cell – relative merits and demerits.

UNIT IV FUEL CELL CHEMISTRY 10

Fuel cell thermodynamics – Gibb's free energy, reversible and irreversible losses, Fuel cell efficiency, Nernst equation – Effect of temperature, pressure and concentration on Nernst potential, Concept of electrochemical potential, Fuel cell reaction kinetics - electrode kinetics, over-voltages, Tafel equation, charge transfer reaction, exchange currents – performance evaluation of fuel cell – Fuel cell characterization: - in-situ and ex-situ characterization techniques, i-V curve, comparison on battery Vs fuel cell.

UNIT V APPLICATION OF FUEL CELL AND ECONOMICS 8

Fuel cell usage for domestic power systems, large scale power generation, Automobile, Fuel cell engine vehicles (FCVs): Fuel cells as alternative to internal combustion buses, Delivery vehicle, Cars and other Automobiles, non-transport applications, Submarines, Hybrid Electric Vehicles (HEVs), Conventional versus hybrid vehicles, Fuel cell engine safety and control, Economic and environmental analysis, Future trends in fuel cells.

TOTAL PERIODS: 45

COURSE OUTCOMES

After completion of the course, students will be able to

CO#	Course Outcomes	Knowledge Level
CO1	gain fundamental knowledge on hydrogen generation/storage technologies.	K2:U
CO2	know the details of different methods of hydrogen storage.	K2:U
CO3	know the thermodynamics of fuel cells.	K2:U
CO4	know the construction and working of different types of fuel cells.	K2:U
CO5	know the applications of fuel cells.	K2:U

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1			3	1	3	
CO2			3	1	3	
CO3			3	1	3	
CO4		1	3	1	3	
CO5		1	3	1	3	

REFERENCE BOOKS

1. Barclay F.J., Fuel Cells, Engines and Hydrogen, Wiley, 2009.
2. Bent Sorensen (Sørensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier, UK 2005.
3. Hart A.B. and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, New

York Ltd., London 1989.
4. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA 2002.
5. Kordesch K. and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany 1996.
6. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma, 2005.
7. Viswanathan B. and Aulice Scibioh.M, Fuel Cells – Principles and Applications, Universities Press, 2006.

COURSE CODE	COURSE TITLE	L	T	P	C
PEY2321	ENERGY CONSERVATION IN ELECTRICAL SYSTEMS	3	0	0	3

OBJECTIVES:

The objective of the course is to introduce students on the basic functional aspects of electrical energy systems with specific attention to transformers, motors, fans, pumps and compressors. The main intent of the course is to make students learn about energy conservation, ENCON, CO_2 mitigation, LEDs and other energy efficient devices.

UNIT I BASICS OF ELECTRICAL ENERGY USAGE 9

Electricity Billing: Components & Costs – kVA – Need &Control – Determination of kVA demand & Consumption – Time of Day Tariff – Power Factor Basics – Penalty Concept for PF – PF Correction- Power factor improvement and its benefit, – Automatic power factor controllers, Demand Side Management (a brief).

UNIT II TRANSFORMERS & MOTORS 9

Transformer: Basics & Types – AVR & OLTC Concepts – Selection of Transformers – Performance Prediction - Energy Efficient Transformers - Distribution and transformer losses Motors: Specification & Selection – Efficiency / Load Curve – Load Estimation – Assessment of Motor Efficiency under operating conditions – Factors affecting performance – Ill effects of Rewinding & Oversizing - Energy Efficient Motors - ENCON Scope.

UNIT III FANS, PUMPS AND COMPRESSORS 10

Basics – Selection – Performance Evaluation – Cause for inefficient operation – Factors Affecting Performance, Scope for energy conservation – Methods (General & Latest) adopted for effecting ENCON – Economics of ENCON adoption in all the three utilities.

UNIT IV ILLUMINATION & ENERGY EFFICIENCY DEVICES 10

Specification of Luminaries – Types – Efficacy – Selection & Application – ENCON Avenues& Economic Proposition - New Generation Luminaries (LED / Induction Lighting), Energy efficient lighting controls (Time Sensors – Occupancy Sensors). Soft Starters / Auto Star – Delta – Star Starters / Automatic Power Factor Control

(APFC) / Variable Speed & Frequency Drives – Maximum demand controllers.

UNIT V CASE STUDIES & CO_2 MITIGATION 7

Case Study Evaluation for 3/4 Typical Sectors – PAT Scheme (an introduction) – CO_2Mitigation, Energy Conservation & Cost Factor. Carbon Trading (a brief).

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students will be able to

CO#	Course Outcomes	Knowledge Level
CO1	understand the basics terms involved in the assessment of electrical energy utilization.	K2:U
CO2	know the functional aspects of transformers and motors.	K2:U
CO3	know the construction and working of fans, pumps and compressors.	K2:U
CO4	undertake energy conservation measures like promotion of efficient LEDs and energy efficient devices.	K3:Ap
CO5	know the methods of CO 2 mitigation.	K2:U

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1			3		3	
CO2			3		3	
CO3			3	1	3	
CO4	1	1	3	1	3	
CO5		1	3	1	3	1

REFERENCES

1. Guide book for National Certification Examination for Energy.
2. Hamies, Energy Auditing and Conservation; Methods Measurements, management andCase Study, Hemisphere, Washington, 1980.
3. Handbook on Energy Efficiency, TERI, New Delhi, 2001.
4. Kraushaar and Ristenen, Energy and Problems of a Technical Society, 1993.
5. Peters et al. Sustainable Energy, beta – test –draft.
6. Trivedi P.R. and Jolka K.R., Energy Management, Commonwealth Publication, NewDelhi, 1997.
7. Managers and Energy Auditors (Could be downloaded from www.energymanagertraining. com)

COURSE CODE	COURSE TITLE	L	T	P	C
PEY2323	ENERGY EFFICIENT BUILDINGS	3	0	0	3

OBJECTIVES:

The objective of this course is to make students learn about green buildings and energy efficientbuilding cooling technologies, estimate thermal loads of building to assess its HVAC requirements.

UNIT I INTRODUCTION **9**

Conventional versus Energy Efficient buildings – Historical perspective - Water – Energy – IAQrequirement analysis – Role of materials & embodied energy – ECBC standards – LEED India.

UNIT II LANDSCAPE AND BUILDING ENVELOPES **9**

Energy efficient Landscape design - Micro-climates – various methods – Shading, water bodies- Building envelope: Building materials, Envelope heat loss and heat gain and its evaluation, paints, Insulation, Design methods and tools.

UNIT III HEATING, VENTILATION AND AIR-CONDITIONING **9**

Natural Ventilation, Passive cooling and heating - Application of wind, water and earth for cooling, evaporative cooling, radiant cooling – Hybrid Methods – Energy Conservation measures, Thermal Storage integration in buildings.

UNIT IV HEAT TRANSMISSION IN BUILDINGS **9**

Surface co-efficient: air cavity, internal and external surfaces, overall thermal transmittance,wall and windows; Heat transfer due to ventilation/infiltration, internal heat transfer; air temperature; Decrement factor; Phase lag. Day lighting integration in Buildings; Estimation of building loads: Computer packages for carrying out thermal design of buildings and predicting performance.

UNIT V PASSIVE COOLING & RENEWABLE ENERGY IN BUILDINGS **9**

Passive cooling concepts: Evaporative cooling, radiative cooling; Application of wind, water and earth for cooling; Shading, paints and cavity walls for cooling; Roof radiation traps; Earth air tunnel. Introduction of renewable sources in buildings, solar water heating, small wind turbines, stand-alone PV systems, Hybrid system – Economics.

TOTAL PERIODS: 45

COURSE OUTCOMES

After completion of the syllabus student will be able to

CO#	Course Outcomes	Knowledge Level
CO1	understand the need for energy efficient buildings.	K2:U
CO2	understand the influence of shading and building materials on thermal response of buildings.	K4:An
CO3	know about HVAC systems for buildings.	K2:U
CO4	Estimate heat load of buildings and suggest methods for minimizing thermal load on buildings.	K4:An

CO5	Know about renewable energy options for the cooling of buildings and active/passive cooling methods for energy conservation in buildings.	K2:U

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1			3	1	3	
CO2			3	1	3	
CO3			3	1	3	
CO4	1	1	3	1	3	
CO5	1	1	3	1	3	

REFERENCE BOOKS

1. Arora C.P, Refrigeration and Airconditioning, Tata McGraw-Hill Publishing Company Ltd., 2000.
2. Franceso Asdrubali Umberto Desideri, handbook of Energy Efficiency in Buildings A life Cycle Approach, Elsevier 2019
3. Krieder J. and Rabi A., Heating and Cooling of buildings : Design for Efficiency, Mc GrawHill, 1994.
4. Ursala Eicker, Solar Technologies for buildings, Wiley publications, 2003.
5. Guide book for National Certification Examination for Energy Managers and EnergyAuditors (Could be downloaded fromwww.energymanagertraining.com)
6. Mili Majumdar, Energy Efficient Buildings in India, TERI Publications, 2009.
7. Arorora C.P., Refrigeration and Airconditioning, Second Edition, Tata McGraw-Hill, 2000.
8. David A. Bainbridge, Ken Haggard, Passive Solar Architecture: Heating, Cooling, Ventilation, Daylighting and More Using Natural Flows, Chelsea Green Publishing Company, 2011.
9. Charles J. Kibert, Sustainable Construction: Green Building Design and Delivery, Wiley Publications, 2012.

COURSE CODE	COURSE TITLE	L	T	P	C
PEY2324	**ADVANCED ENERGY STORAGE TECHNOLOGIES**	**3**	**0**	**0**	**3**

OBJECTIVES:

The objective of the course is to introduce students about various energy storage technologiesand applications.

UNIT I INTRODUCTION **9**

Necessity of energy storage – types of energy storage – comparison of energy storagetechnologies – Applications.

UNIT II THERMAL STORAGE SYSTEMS **9**

Thermal storage – types – principle, construction and working - simple water and

rock bedstorage system – pressurized water storage system – phase change storage system – merits and demerits, configurations, applications – waste heat recovery and thermal management - performance enhancement methods.

UNIT III CHEMICAL ENERGY STORAGE 9

Chemical bond energy storage, solar energy-photosynthesis, Chemical-Thermal, Chemical-Electrical, hydrogen – storage and utilization, chemical storage in gas/liquid/solid fuels – storage and utilization, issues in chemical energy storage.

UNIT IV ELECTROCHEMICAL ENERGY STORAGE 10

Principles of electrochemical storage – batteries - types of batteries – lead acid, nickel – cadmium, zinc manganese dioxide, zinc-air, nickel hydride, lithium- ion, sodium-ion and flow batteries – battery terminologies, battery performance, charging and discharging of a battery, , fuel cell – history of fuel cell, types - safety issues.

UNIT V ALTERNATE ENERGY STORAGE TECHNOLOGIES 8

Hydro storage, Gravitational potential energy, Pumped Energy Storage, Flywheel, capacitor, supercapacitor, ultracapacitors Principles & Methods – Applications, Compressed air energystorage, Super conducting magnetic energy (SMES) storage.

TOTAL PERIODS 45

COURSE OUTCOMES

On successful completion of this course, the student will be able to

CO#	Course Outcomes	Knowledge Level
CO1	gain fundamental knowledge on hydrogen generation/storage technologies.	K2:U
CO2	know the details of different methods of hydrogen storage.	K2:U
CO3	know the thermodynamics of fuel cells.	K2:U
CO4	know the construction and working of different types of fuel cells.	K2:U
CO5	know the applications of fuel cells.	K2:U

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1			3		3	
CO2			3	1	3	
CO3			3	1	3	
CO4		1	3	1	3	
CO5		1	3	1	3	

REFERENCE BOOKS

1. Ibrahim Dincer and Mark A. Rosen, “Thermal Energy Storage Systems and

Applications",John Wiley & Sons 2002.
2. James Larminie and Andrew Dicks, "Fuel cell systems Explained", Wiley publications,2003.
3. Lunardini.V.J, Heat Transfer in Cold Climates, John Wiley and Sons 1981.
4. Ru-shiliu, Leizhang and Xueliang sun, "Electrochemical technologies for energy storage andconversion", Wiley publications, 2012.
5. Schmidt.F.W and Willmott.A.J, Thermal Storage and Regeneration, Hemisphere PublishingCorporation, 1981.

COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
PEY2327	ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL	PE	3	0	0	3

OBJECTIVES:

The objective of the course is to introduce students about various environmental pollutions,waste management and disposal.

UNIT I INTRODUCTION **9**

Global atmospheric change – green house effect – Ozone depletion - natural cycles - mass and energy transfer – material balance – environmental chemistry and biology – impacts – environmental legislations.

UNIT II AIR POLLUTION **9**

Pollutants - sources and effect – air pollution meteorology – atmospheric dispersion – indoor air quality - control methods and equipments - issues in air pollution control – air sampling and measurement.

UNIT III WATER POLLUTION **9**

Water resources - water pollutants - characteristics – quality - water treatment systems – waste water treatment - treatment, utilization and disposal of sludge - monitoring compliance with standards.

UNIT IV SOLID WASTE MANAGEMENT **9**

Sources and Classification – Solid waste – Hazardous waste - Characteristics – Collection andTransportation - Disposal – Processing and Energy Recovery – Waste minimization**.**

UNIT V WASTE DISPOSAL TECHNOLOGIES **9**

Definition – Sources – Classification – Incineration Technology - Incineration vs Combustion Technology – Refuse Derived Fuel (RDF), Mass Firing – Material Recycling : Paper / Glass / Plastics etc., - Disposal of White Goods & E-Wastes.

TOTAL PERIODS 45

COURSE OUTCOMES

On successful completion of this course, the student will be able to

CO#	Course Outcomes	Knowledge Level
CO1	Get an insight about greenhouse effect, global warming, ozone depletion	K2: U
CO2	Know about air pollution and methods of monitoring and controlling	K2: U
CO3	Know about water pollution, wastewater treatment and sludge disposal	K2: U
CO4	Know about solid waste management	K2: U
CO5	Know about different waste disposal technologies.	K2: U

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1			3	1	3	
CO2	1		3	3	3	
CO3			3	3	3	
CO4	1	1	3	3	3	
CO5	1	1	3	3	3	

REFERENCE BOOKS

1. Arcadio P Sincero and G.A. Sincero, Environmental Engineering – A Design Approach,Prentice Hall of India Pvt Ltd, New Delhi, 2002.
2. Bishop P., Pollution Prevention: Fundamentals and Practice, McGraw-Hill InternationalEdition, McGraw-Hill book Co, Singapore, 2000.
3. G. Masters, Introduction to Environmental Engineering and Science Prentice Hall of IndiaPvt Ltd, New Delhi, 2003.
4. Gilbert M. Masters, Introduction to Environmental Engineering and Science, 2nd Edition,Prentice Hall, 1998.
5. H. Ludwig, W.Evans, Manual of Environmental Technology in Developing Countries,International Book Company, Absecon Highlands N.J. (1991).
6. H.S. Peavy, D.R.Rowe and G. Tchobanoglous, Environmental Engineering McGraw-Hill Book Company, NewYork, (1985).
7. Rao C.S., Environmental Pollution Control Engineering, 2nd Edition, New Age InternationalPublishers, 2006.

COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
PEY2328	**WASTE MANAGEMENT AND ENERGY RECOVERY**	**PE**	**3**	**0**	**0**	**3**

OBJECTIVES:

The objective of the course is to introduce students about various types of wastes, their processing, disposal, recycling and effective management.

UNIT I CHARACTERISTICS AND PERSPECTIVES 9

Sources of wastes – Types – Composition – Generation – Estimation Techniques –

Characterization – Types of Collection System – Transfer Stations – Transfer Operations – Material Recycle / Recovery Facilities.

UNIT II UNIT OPERATIONS & TRANSFORMATION TECHNOLOGIES 8

Productive collection system - Separation & Processing: Size Reduction – Separation through Density Variation, Inertia - Magnetic /Electric Field: Densification - Physical, Chemical and Biological Properties and Transformation Technologies – Selection of Proper Mix of Technologies.

UNIT III WASTE DISPOSAL 9

Landfill Classification – Types – Siting Considerations – Landfill Gas (Generation, Extraction, Gas Usage Techniques) – Leachates composition and characterization, Movement, Control Techniques – Environmental Quality Monitoring – Layout, Closure & Post Closure Operation – Reclamation.

UNIT IV TRANSFORMATION TECHNOLOGIES AND VALUE ADDITION 10

Physical Transformation: Component Separation and Volume Reduction: Chemical Transformation – Combustion/Gasification/ Pyrolysis: Energy Recovery - Biological Transformation – Aerobic Composting – Anaerobic Digestion.

UNIT V HAZARDOUS WASTE MANAGEMENT & WASTE RECYCLING 9

Definition – Sources – Classification – Incineration Technology - Incineration vs Combustion Technology – RDF / Mass Firing – Material Recycling: Paper / Glass / Plastics etc., - Disposal of White Goods, Electronic -Wastes (e- waste) - Management of electronic wastes - Radioactive waste management.

TOTAL PERIODS 45

COURSE OUTCOMES

On successful completion of this course, the student will be able to

CO#	Course Outcomes	Knowledge Level
CO1	know about the different types of wastes and sources	K2: U
CO2	know different separation and processing of wastes	K2: U
CO3	know different waste disposal and processing methods	K2: U
CO4	know on the waste transformation technologies like combustion and gasification	K2: U
CO5	know about the risks involved in waste handling and methods of recycling of wastes	K2: U

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	1		3	1	3	
CO2	1		3	1	3	
CO3	1		3	1	3	
CO4	1	1	3	1	3	

CO5	1	1	3	2	3	

REFERENCE BOOKS

1. Charles R. Rhyner, Leander J. Schwartz, Robert B. Wenger, Mary G. Kohrell, Waste Management and Resource Recovery, 2017.
2. Deepak Yadav, Pradeep Kumar, Pardeep Singh, Daniel A. Vallero, Hazardous Waste Management: An Overview of Advanced and Cost-Effective Solutions, 2021
3. Energy Cogeneration Handbook, George Polimveros, Industrial Press Inc, New York 1982.
4. Howard S. Peavy et al, "Environmental Engineering", McGraw Hill International Edition, 1985.
5. LaGrega, M., et al., "Hazardous Waste Management", McGraw-Hill, c. 1200 pp., 2nd ed.,2001.
6. Manoj Datta, "Waste Disposal in Engineered Landfills", Narosa Publishing House, 1997.
7. Parker Colin and Roberts, "Energy from Waste – An Evaluation of Conversion Technologies", Elsevier Applied Science, London, 1985.
8. Stanley E. Manahan, "Hazardous Waste Chemistry, Toxicology and Treatment", Lewis Publishers, Chelsea, Michigan, 1990.
9. Tchobanoglous, Theisen and Vigil, "Integrated Solid Waste Management", 2d Ed. McGraw-Hill, New York, 1993.

COURSE CODE	COURSE TITLE	L	T	P	C
PEY2329	NANOMATERIALS FOR ENERGYAND ENVIRONMENT	3	0	0	3

OBJECTIVES:

The objective of the course is to introduce students about nanomaterials, its characterization/analysis and their application in solar cells, energy storage and conversion devices, microfuel cells, biofuels and carbon capture. The course also is intended to highlight thesafety aspects and health issues as regards nanomaterials.

UNIT I NANOMATERIALS 9

Classification and Properties of nanomaterials. Characteristics of nanomaterials - Bottom-Up Synthesis - Top-Down Synthesis. Nano characterization - Electron Microscopic Analysis: Scanning Electron Microscopy (STM) and Transmission Electron Microscopy (TEM) approach -Atomic Force Microscopic Analysis - X-ray Diffraction Analysis - Spectroscopic Analysis.

UNIT II NANOMATERIALS APPLIED IN SOLAR CELLS 8

Thermodynamics of solar energy - Nano, micro, and poly crystalline and amorphous Si for solar cells, nano-micro-Si-composite structure, various techniques of Si deposition. Nanostructured Materials for PV cells – Crystalline silicon PV – Organic PV – Dye-

Sensitized PV – Perovskite solar cells

UNIT III NANOMATERIALS FOR ENERGY STORAGE AND CONVERSION DEVICES 12

Carbon Materials- Carbon Nanotubes, Graphene, CNT/Graphene Hybrid, Carbon Fiber, Carbon Grease- Conjugated Polymer- Metal Oxides- Lithium Metal Oxides- Elemental and Compound Semiconductors- Metals. Piezoelectric Nanomaterials- Properties and Synthesis of Piezoelectric Nanomaterials- Energy Harvesting with Piezoelectric Nanomaterials. Nanomaterials for Rechargeable Lithium Batteries- Positive Electrode Materials- Negative Electrode Materials.

UNIT IV MICRO FUEL CELL TECHNOLOGY 8

Micro fuel cell technologies, integration and performance for micro-fuel cell systems -thin film and microfabrication methods - design methodologies – micro fuel cell power sources. Incorporating Graphene into Fuel Cell Design, Mesoporous Materials for Fuel Cells. Nanomaterials for Hydrogen Generation from Solar Water Splitting.

UNIT V NANOMATERIALS AND ENVIRONMENTAL IMPACT 9

Nanomaterials in environment, environmental life cycle of nano materials, environmental and health impacts of nano materials, toxicological threats, eco-toxicology, exposure to nano particles – biological damage, threat posed by nano materials to humans, environmental reconnaissance and surveillance, nanomaterials for air pollution remediation- water pollutant removal applications-

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students will be able to

CO#	Course Outcomes	Knowledge Level
CO1	Theoretically know about the classification and characterization of different nanomaterials	K2: U
CO2	Know about nano materials for Solar cell applications	K2: U
CO3	Know on the application of nanoscience to energy storage devices like batteries	K2: U
CO4	Gain fundamental knowledge on micro fuel cell technology	K2: U
CO5	Know about biofuel production and carbon capture with nanomaterials and associated safety/health issues of nanomaterials	K2: U

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	1		3		3	
CO2	1		3		3	
CO3	1		3		3	

CO4	1	1	3		3	
CO5	1	1	3	2	3	

REFERENCES

1. Jingbo Louise Liu, Sajid Bashir, Advanced Nanomaterials and Their Applications in Renewable Energy, 2015
2. Jun Hieng Kiat, Nanomaterials in Energy Devices, 2017
3. Garcia-Martinez J., Nanotechnology for the Energy Challenge, Wiley-VCH, Weinheim,2010.
4. Hari Singh Nalwa, Nanomaterials for Energy Storage Applications, Nanomax Technologies, USA, 2009.
5. Hoogers, Fuel cell technology handbook, CRC Press, 2003.
6. Li Quan (Ed.), Nanomaterials for Sustainable Energy, ISBN 978-3-319-32023-6, Springer Publications, 2016.
5. Martin A Green, Solar cells: Operating principles, technology and system applications, Prentice Hall Inc, Englewood Cliffs, NJ, USA, 1981.
6. Tsakalakos L., Nanotechnology for Photovoltaics, CRC, 2010.
7. Twidell J and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, 1986.
8. Vayssieres L., On Solar Hydrogen and Nanotechnology, Wiley, 2009.

COURSE CODE	COURSE TITLE	L	T	P	C
PEY2336	**POWER GENERATION, TRANSMISSION AND UTILIZATION**	**3**	**0**	**0**	**3**

OBJECTIVES:

The objective of the course is to make students learn about conventional and non-conventionalpower generation, power transmission, utilization and economics of power generation.

UNIT I CONVENTIONAL POWER GENERATION **11**

Steam power plant - Selection of site - Generated layout - Coal and ash handling - Steam Generating Plants - Feed Make Circuit - Cooling Towers - Turbine Governing - Hydroelectric Power Generation – Selection of Site, Components, and control system - Gas Turbine Plants.

UNIT II NON CONVENTIONAL POWER GENERATION **8**

Wind power generation - characteristics of wind power-design of windmills, Solar power generation – Solar PV – Stand alone and Hybrid system, Advanced Energy Technologies – Battery (Lead–Acid Batteries and Lead–Acid Batteries) and Fuel cells (PEM and SOFC).

UNIT II ELECTRICAL POWER TRANSMISSION **11**

Online diagram of transmission - substation and distribution systems - comparison of systems (DC and AC) - EHVAC and HVDC transmission - layout of substations and bus

bar arrangements - Equivalents circuit of short, medium and long lines - Transmission efficiency- regulation-reactive power - compensation-transmission - loss minimization.

UNIT IV UTILISATION OF ELECTRICAL ENERGY 9

Selection of Electrical Drives - Electrical characteristics and mechanical considerations - size, rating and cost, Transformer characteristics – illumination - laws of illumination-polar curve – incandescent - fluorescent and vapour lamps - Design of OLTC lighting Scheme of industry- electrical welding - energy efficient aspects of devices.

UNIT V ECONOMICS OF POWER GENERATION
6

Daily load curves - load factor - diversity factor - load deviation curve - load management - number and size of generating UNIT, cost of electrical energy – tariff - power factor improvement.

TOTAL PERIODS: 45

COURSE OUTCOMES

Students, upon completion of this course will be able to

CO#	Course Outcomes	Knowledge Level
CO1	know conventional power generation systems.	K2:U
CO2	know about non-conventional power generation systems.	K2:U
CO3	familiarize about electrical power transmission and challenges.	K2:U
CO4	know about different electrical power utilities.	K2:U
CO5	perform power tariff calculations and economic analysis of power generation.	K3: Ap

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1			3	1	3	
CO2			3	1	3	
CO3			3	1	3	
CO4		1	3	1	3	
CO5		1	3	1	3	

REFERENCE BOOKS

1. Leonard L. Grigsby, Electric Power Generation, Transmission, and Distribution, Electric Power Engineering Handbook Second Edition, CRC Press Taylor & Francis Group, 2007.
2. Krishnan. R, Electric Motor Drives, Prentice hall, 2001.
3. Mohammed E. Hawary, Introduction to Electrical Power Systems, John Wiley & Sons,2008.
4. Rai G.D., Non Conventional Energy Sources, Khanna Publishers, 1993.
5. Rakosh Das Begamudre, Energy Conversion Systems, New Age International, 2007.

6. Singh. S.N, Electrical Power generation, Transmission and Distribution, 2nd Edition, PHILearning Private Limited, 2010.
7. Soni M.L., Gupta P.V., Bhatnagar U.S. and Chakrabarti S., A Text Book on Power SystemEngineering, Dhanpatrai and Co, New Delhi, 2008
8. Twidell J.W and Weir A.D, Renewable Energy Sources, Taylor and Francis, 2006.
9. Wadhwa C.L, Generation Distribution and utilization of Electrical Energy, New AgeInternational, 2012.

Mapping of courses- B.E. Electrical & Electronics Engg.

	Sustainable Development Goals																
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Generation, Transmission and Distribution								✓	✓								
Solar Energy Systems							✓	✓	✓		✓	✓					
Energy Resources and Utilization							✓	✓	✓		✓	✓					
Wind Energy Conversion Systems							✓	✓	✓		✓	✓					
Energy Storage Systems							✓	✓	✓		✓	✓					
Electric Vehicle and Power Management							✓	✓	✓		✓	✓					
Energy Management and Auditing											✓	✓					
Autonomous vehicles								✓	✓		✓						✓
Energy Management											✓	✓					
Renewable Energy systems							✓	✓	✓		✓	✓					

Course Code	**Course Title**	**L**	**T**	**P**	**C**
UEE2403	**GENERATION TRANSMISSION AND DISTRIBUTION**	4	0	0	4

Objectives:

- To introduce various electric power generation principle along with computation of electric power tariff.
- To determine the various electrical parameter and to compute electrical performance of overhead transmission line
- To explain the role of insulators in OHTL and underground cables.

• To study about DC and AC distribution systems along with various techniques for voltage and power factor improvement.		
Unit I	**GENERATION PRINCIPLES**	**12**
Hydro-electric power plants - Thermal power plants - Nuclear power plants – Renewable Power Plant – Operation – Selection of Site - Power tariff types		
Unit II	**TRANSMISSION LINE PARAMETER**	12
Structure of electric power system - Types of AC and DC distributors - EHVAC and HVDC transmission - Resistance, Inductance and Capacitance calculations – Single-phase and three phase lines – double circuit lines – effect of earth on transmission line capacitance - corona & proximity effect		
Unit III	**PERFORMANCE OF TRANSMISSION LINE**	12
Modeling of Transmission Line - short, medium and long transmission lines - Regulation and efficiency – ABCD constants - Power flow through a transmission line - surge impedance loading – Ferranti effect		
Unit IV	**MECHANICAL DESIGN OF TRANSMISSION LINE AND CABLES**	12
Mechanical design of transmission line – sag and tension calculations for different weather conditions, Tower spotting, Types of towers Insulators, Voltage distribution in suspension insulators – string efficiency – improving string efficiency - testing of insulators Underground cables – Types of cables – insulation resistance – dielectric stress – grading of cables - capacitance grading - intersheath grading.		
Unit V	**DISTRIBUTION SYSTEMS**	12
General aspects – DC distribution systems - concentrated and distributed loads - radial and ring main systems – A.C. distribution – Single-phase and three phase		
	Total Periods	60
Course Outcomes: Upon successful completion of the course, students will be able to		
CO1: Understand the principles of power generation and various power tariff.		
CO2: Determine the various transmission line parameters.		
CO3: Analyze the performance of overhead transmission line.		
CO4: Compute the voltage distribution, string efficiency, and dielectric stress for OHTL and Cables.		
CO5: Analyze the performance of DC and AC distribution systems		
CO6: Evaluate and Summarize the concepts of transmission and distribution for a specific real time problem.		
Text Books:		
1. Leonard L. Grigsby, “Electric Power Generation, Transmission, and Distribution”, CRC Press; 1st edition, 2007.		
2. Wadhwa, C.L., ‘Generation Distribution and Utilization of Electrical Energy', New Age International Publishers, 3rd Edition, 2010.		

3. S.N. Singh, 'Electric Power Generation, Transmission and Distribution', Prentice Hall of India, Second edition 2008.

References:

1. S. Sivanagaraju and S. Sathyanarayana, 'Electric Power Transmission and Distribution', Pearson, 2009.
2. V.K. Mehta and Rohit Mehta, ' Principles of Power System', S. Chand, 2013
3. C L Wadhwa, “Electrical Power Systems”, New Age Internationals; First Edition 2016
4. Gupta B.R., 'Power system Analysis & Design', S. Chand and Company Ltd., Re-issue Edition, 2005.

COs	Pos												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3		1	3			1						
2	3	3	2	1	3			1						
3	3	3	2	1	3			1					1	
4	3	3	2	1	3			1						
5	3	3		1	3			1						

Course Code	Course Title	L	T	P	C
UEE2521	SOLAR ENERGY SYSTEMS	3	0	0	3

Objectives:

- To study about solar cells and photovoltaic system design for standalone and grid connected applications
- To understand different applications of photovoltaic system.

Unit I	INTRODUCTION	9

Characteristics of sunlight – semiconductors and P-N junctions –behaviour of solar cells – cell properties and design – PV Cell interconnection and module fabrication.

Unit II	STAND ALONE PHOTOVOLTAIC SYSTEM	9

Standalone PV system design - Solar modules – storage systems – power conditioning and regulation - Balance of system components – Designing standalone PV systems – sizing.

Unit III	GRID CONNECTED PHOTOVOLTAIC SYSTEMS	9

PV systems in buildings – utility applications for photovoltaics - design issues for central power stations – safety – Economic aspect –standards and guidelines for PV systems, Efficiency and performance - International PV programs.

Unit IV	PHOTOVOLTAIC WATER PUMPING SYSTEM COMPONENTS	9
System configuration - Water Pumps - Motors - Power conditioning circuitry - Batteries - Array wiring and mounting - PV water pumping system design -Example of a directly coupled system design.		
Unit V	**SOLAR APPLICATIONS**	**9**
Space - Marine - Telecommunications - Photovoltaic powered transport - Solar Cars - Solar Furnaces - Solar Refrigeration.		
	Total Periods	**45**

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

CO1: Explain the characteristics, techniques of solar energy conversion system and PV module fabrication

CO2: Design a standalone photovoltaic system

CO3: Describe a grid connected photovoltaic system and identify the challenges

CO4: Design a PV water pumping system

CO5: Discuss the applications of solar energy

Text Books:

1. Stuart R.Wenham, Martin A.Green, Muriel E. Watt, Richard Corkish and Alistair Sproul, "Applied Photovoltaics", Third Edition, 2011,Earthscan, UK.

2. Solanki C.S., “Solar Photovoltaics: Fundamentals, Technologies And Applications”, PHI Learning Pvt. Ltd., 2015.

References:

1. Eduardo Lorenzo G. Araujo, Solar electricity engineering of photovoltaic systems, Progensa,1994.

2. Solar & Wind Energy Technologies – McNeils, Frenkel, Desai, Wiley Eastern, 1990

3. S.P. Sukhatme , “Solar Energy”, Tata McGraw Hill,1987.

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3												1	2
2	3	3	2	3	2				2	1		1	1	2
3	3	3	2	3	2				2	1		1	2	3
4	3	3	2	3	2		2		2	1		1	2	2
5	3	3	2	3	2		2		2	1		1	1	3

Course Code	Course Title	L	T	P	C
UEE2523	ENERGY RESOURCES AND UTILIZATION	3	0	0	3

Objectives:

- To introduce energy scenario and to discuss various commercial energy available in India
- To introduce renewable energy source like Solar and Wind
- To discuss utilization of electrical energy based on domestic consumers.
- To discuss utilization of electrical energy with respect to refrigeration and air conditioning
- To explain industrial utilization and traction of electrical energy

Unit I	**COMMERCIAL ENERGY**	**9**

Coal, Oil, Natural gas, Nuclear power and Hydro - their utilization pattern in the past, present and future projections of consumption pattern - Sector-wise energy consumption – environmental impact of fossil fuels – Energy scenario in India – Growth of energy sector and its planning in India.

Unit II	**RENEWABLE ENERGY**	**9**

Solar radiation at the earth's surface – solar radiation measurements – estimation of average solar radiation -principle of photovoltaic conversion of solar energy, types of solar cells – Nature of the wind – power in the wind – factors influencing wind – wind data and energy estimation - wind speed monitoring - wind resource assessment - Betz limit - site selection - wind energy conversion devices - classification, characteristics

Unit III	**DOMESTIC UTILIZATION AND ILLUMINATION**	**9**

Online and OFF line UPS, Batteries - Power quality aspects – nonlinear and domestic loads – Earthing – Importance of lighting –laws of illumination –types of lamps – lighting calculations – basic design of illumination schemes for residential, commercial, street lighting, factory lighting and flood lighting – LED lighting and energy efficient lamps.

Unit IV	**REFRIGERATION AND AIR CONDITIONING**	**9**

Refrigeration-Domestic refrigerator and water coolers - Air-Conditioning-Various types of air-conditioning system and their applications, smart air conditioning units - Energy Efficient motors: Standard motor efficiency, need for efficient motors, Motor life cycle, Direct Savings and payback analysis, efficiency evaluation factor.

Unit V	**INDUSTRIAL UTILIZATION AND TRACTION**	**9**

Role of electric heating for industrial applications – resistance heating – induction heating – dielectric heating. Brief introduction to electric welding – welding generator, welding transformer and the characteristics.Merits of electric traction – requirements of electric traction system – supply systems – mechanics of train movement – traction motors and control – braking – recent trends in electric traction.

Total Periods	**45**

Course Outcomes: Upon successful completion of the course, students will be able to
CO1: Discuss the basics of commercial energy and their utilization pattern and future projections of consumption pattern with respect to Indian scenario.
CO2: Demonstrate the renewable energy resources like solar and wind and their electrical conversion.
CO3: Explain the domestic utilization of electricity in particular to UPS, and power quality issues along with illumination techniques and LED lightning.
CO4: Explain the refrigeration and air conditioning system, along with energy efficient motors and their saving in energy utilization.
CO5: Explain the industrial utilization of electricity in particular toheating, welding and electric traction.
Text Books:
1. Wadhwa, C.L. "Generation, Distribution and Utilization of Electrical Energy", New Age International Pvt. Ltd, 2003.
2.Dr. Uppal S.L. and Prof. S. Rao, 'Electrical Power Systems', Khanna Publishers, New Delhi, 15th Edition, 2014.
3. Bent Sorensen , “Renewable Energy”, Elsevier, Academic Press, 2011.
4. Kishore V.V.N., “Renewable Energy Engineering and Technology”, Teri Press, New Delhi,2012
References:
1. Partab.H, "Art and Science of Utilisation of Electrical Energy", Dhanpat Rai and Co, New Delhi, 2004.
2. Openshaw Taylor.E, "Utilization of Electrical Energy in SI Units", Orient Longman Pvt. Ltd, 2003.
3.Gupta.J.B, "Utilization of Electric Power and Electric Traction", S.K.Kataria and Sons, 2002.
4.Sukhatme S.P., “Solar Energy”, Tata McGraw Hill, 1984.
5.Twidell J.W. and Weir A., “Renewable Energy Sources”, EFN Spon Ltd., 1986.
6.Veziroglu T.N., Alternative Energy Sources”, Vol 5 and 6, McGraw-Hill, 1990.

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3						2				1		
2	3	3	1					2					2	1
3	3	3	1	1				2				2	1	2
4	3	3	1	1				2				2		
5	3	3						2				2	1	1

Course Code	Course Title	L	T	P	C
UEE2621	**WIND ENERGY CONVERSION SYSTEMS**	**3**	**0**	**0**	**3**

Objectives:

- To learn the design and control principles of Wind turbine.
- To understand the concepts of fixed speed and variable speed wind energy conversion systems.
- To analyze the grid integration issues.

Unit I	**INTRODUCTION**	**9**

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory - Power coefficient- Sabinin'stheory-Aerodynamics of Wind turbine.

Unit II	**WIND TURBINES**	**9**

HAWT-VAWT-Power developed -Thrust-Efficiency-Rotor Selection-Rotor design considerations Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control stall control-Schemes for maximum power extraction.

Unit III	**FIXED SPEED SYSTEMS**	**9**

Generating Systems- Constant speed constant frequency systems -Choice of Generators - Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model- Generator model for Steady state and Transient stability analysis.

Unit IV	**VARIABLE SPEED SYSTEMS**	**9**

Need of variable speed systems-Power-wind speed characteristics - Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modelling - Variable speed variable frequency schemes.

Unit V	**GRID CONNECTED SYSTEMS**	**9**

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modelling issue.

Total Periods	**45**

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

CO1:Acquire knowledge on the basic concepts of wind energy conversion system

CO2: Demonstrate the types of wind turbine and aero dynamics

CO3: Explain the principle of fixed speed system.

CO4: Illustrate the working and design of variable speed system.

CO5: Analyze the grid integration issues and current practices of wind interconnection.

Text Books:

1.L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990

2.S.N.Bhadra, D.Kastha, S.Banerjee,"Wind Electrical Sytems",Oxford University Press,2010.

References:

1. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.

2.E.W.Golding "The generation of Electricity by wind power", Redwood burn Ltd.,Trowbridge,1976

3. N. Jenkins," Wind Energy Technology" John Wiley & Sons,1997

4.S.Heir "Grid Integration of WECS", Wiley 1998.

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	2												1	2
2	3	2	1											2
3	3	2	2	3								2		2
4	3	2	2	3								2	2	3
5	3	2	2	3	3				2	1		2	2	3

Course Code	Course Title	L	T	P	C
UEE2626	**ENERGY STORAGE SYSTEMS**	**3**	**0**	**0**	**3**

Objectives:

- To understand the concepts and technologies used in various multidisciplinary energy storage devices.
- To understand selection and sizing of a suitable energy storage device for a specific application.
- To learn the energy storage management for grid connected power systems.

Unit I	**THERMAL ENERGY STORAGE**	**9**

Thermal Energy - Principle - Benefits - Criteria for Evaluation - Operating Characteristics - Sensible, Latent and Cold Thermal Energy Storage - Heating and Cooling Applications

Unit II	**ELECTROCHEMICAL ENERGY STORAGE**	**9**

Battery composition, Construction and Principle of operation of Secondary batteries - Modern batteries - Flow batteries - High temperature batteries; Fuel Cells - Operation, Types

Unit III	**ELECTROMAGNETIC ENERGY STORAGE**	**9**

Energy Storage in Capacitors - Supercapacitors - Principle - Charging and Discharging Characteristics - Types - Equivalent Circuits; Superconducting magnetic energy storage - Principles - Superconducting coils - Cryogenic systems- Energy transfer efficiency

Unit IV	**MECHANICAL ENERGY STORAGE**	**9**

Flywheel storage - Structure - System dynamics - Operation; Compressed air energy storage- Principle - Function - Technical characteristics; Pumped hydro storage - Principle - power extraction system		
Unit V	**ENERGY STORAGE MANAGEMENT**	**9**
Techno-Economic Analysis - Estimation of Energy Storage - Dynamic Energy Storage Management for dependable Renewable Electricity Generation - Energy Storage Installations in the Power System - Grid Tied AC Microgrid Applications		
	Total Periods	**45**
Course Outcomes: Upon successful completion of the course, students will be able to		
CO1: Describe the thermal energy storage systems and their applications.		
CO2: Illustrate the operating principles of electrochemical energy storage systems.		
CO3: Summarize the principles underpinning the operation of electromagnetic energy storage systems.		
CO4: Explain the operation of mechanical energy storage systems.		
CO5: Solve the grid integration issues of renewable energy sources by energy storage techniques.		
Text Books:		
1. J. K. Kaldellis, Stand-alone and Hybrid Wind Energy Systems -Technology, Energy Storage and Applications, Woodhead Publishing Series in Energy, CRC Press, 2010		
2. Rosario Carbone, Energy Storage in the Emerging Era of Smart Grids, 2011, InTech		
References:		
1. Frank S. Barnes & Jonah G. Levine, Large Energy storage Systems Handbook, CRC Press, 2011.		
2. Ziad Melhem, Electricity transmission, distribution and storage systems, Woodhead Publishing Series in Energy, 2013.		
3. H. P. Garg, S. C. Mullick, A. K. Bhargava, Solar Thermal Energy Storage,Springer, 1985.		
4. Artur Braun,Electrochemical Energy Systems- Foundations, Energy Storage and Conversion, De Gruyter, CPI Books, 2018.		
5. Robert A. Huggins, Energy Storage, Springer, 2010.		

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1		3	2	2	2								1	3
2		3	2	2	2									2
3		3	2	2	2								1	2
4		3	2	2	2									2

5		3	3	2	2					2			2	3

Course Code	**Course Title**	**L**	**T**	**P**	**C**
UEE2821	**ELECTRIC VEHICLES AND POWER MANAGEMENT**	**3**	**0**	**0**	**3**

Objectives:

- To provide knowledge about electric vehicle architecture and power train components.
- To know the concepts of dynamics of electrical vehicles
- To impart knowledge on vehicle control for standard drive cycles of hybrid electrical vehicles(HEVs)
- To understand the concept of energy storage systems.
- To provide knowledge about different energy sources and energy management in HEVs.

Unit I	**HYBRID ELECTRIC VEHICLE ARCHITECTURE AND POWER TRAIN COMPONENTS**	**9**

History of evolution of Electric Vehicles - Comparison of Electric Vehicles with Internal Combustion Engines - Architecture of Electric Vehicles (EV) and Hybrid Electric Vehicles (HEV) – Plug-in Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes – Tamil Nadu Electric Vehicle Policy

Unit II	**MECHANICS OF HYBRID ELECTRIC VEHICLES**	**9**

Fundamentals of vehicle mechanics - tractive force, power and energy requirements for standard drive cycles of HEV's - motor torque and power rating and battery capacity.

Unit III	**CONTROL OF DC AND AC MOTOR DRIVES**	**9**

Speed control for constant torque, constant HP operation of all electric motors - DC/DC chopper based four quadrant operation of DC motor drives, inverter based V/f Operation (motoring and braking) of induction motor drives, vector control operation of Induction motor and PMSM, Brushless DC motor drives, Switched reluctance motor (SRM) drives

Unit IV	**ENERGY STORAGE SYSTEMS**	**9**

Battery: Principle of operation, types, models, estimation of parameters, battery modeling, SOC of battery, Traction Batteries and their capacity for standard drive cycles, Vehicle to Grid operation of EV's. Alternate sources: Fuel cells, Ultra capacitors, Fly wheels.

Unit V	**HYBRID VEHICLE CONTROL STRATEGY AND ENERGY MANAGEMENT**	**9**

HEV supervisory control - Selection of modes - power spilt mode - parallel mode - engine brake mode - regeneration mode - series parallel mode - energy management of HEV's.

Total Periods	**45**

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

CO1: Illustrate the electric vehicle architecture and power train components.

CO2: Illustrate the concepts of electric vehicle dynamics.
CO3: Examine the AC and DC motor drive controls employed in electric vehicles.
CO4: Describe the energy storage systems used in electric vehicles.
CO5: Summarize the mode selection methods and energy management methods in hybrid electric vehicles.
Text Books:
1. Iqbal Husain, 'Electric and Hybrid Electric Vehicles', CRC Press, 2011.
2. M. Ehsani, Y. Gao, S. Gay and Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC Press, 2015.
References:
1. Wei Liu, 'Hybrid Electric Vehicle System Modeling and Control', Second Edition, Wiley, 2017.
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
3. Iqbal Hussain, "Electric & Hybrid Vechicles – Design Fundamentals", Second Edition, CRC Press, 2011.
4. Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013.

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	2												1
2	3	2	3		2								1	2
3	3			2	2	1	1		1		1			2
4	3	2	3	2	2	1	1		1		1		1	2
5	3		3	2	2	1	1		1		1		2	3

Course Code	**Course Title**	**L**	**T**	**P**	**C**
UEE2823	**ENERGY MANAGEMENT AND AUDITING**	**3**	**0**	**0**	**3**

Objectives:

To explain the Energy management and auditing process.

- To introduce energy management in electrical system
- To discuss energy management techniques with respect to motor and lightning loads.
- To discuss energy management techniques for buildings.
- To explain energy audit process.

Unit I	**ENERGY MANAGEMENT IN ELECTRICAL SYSTEMS**	**9**

Electricity billing - Power Factor improvements and benefits - transformers - distribution loss in industrial system - Assessment of T&D losses in power systems - Demand side management

Unit II	**ELECTRIC ENERGY MANAGEMENT FOR MOTOR LOADS**	**9**
Effects of Unbalanced Voltages on the Performance of Motors - Determining Electric Motor Operating Loads - Motor Efficiency Management - Motor Performance Management Process		
Unit III	**ELECTRIC ENERGY MANAGEMENT FOR LIGHTNING SYSTEMS**	**9**
Basic parameters and terms - light sources and lamp types - Methods of calculating luminance - energy efficient lightning controls - standards and labelling programs		
Unit IV	**ENERGY MANAGEMENT IN BUILDINGS**	**9**
Energy conservation building code (ECBC) - Guidelines on heating ventilation, Air conditioning system, water pumping system, Uninterruptible power supply, escalators and elevators - Energy efficiency measures in buildings - Energy performance assessment and energy savings measures of DG sets		
Unit V	**ENERGY AUDIT**	**9**
Energy Audit definition - Need for energy audit - Types of energy audit and approach - benchmarking - Bureau of energy efficiency regulation 2008 - energy monitoring and targeting - Energy management information system (EMIS)		
	Total Periods	**45**
Course Outcomes: Upon successful completion of the course, students will be able to		
CO1: Explain the concept of electricity billing, power factor improvement and demand side management		
CO2: Describe the energy performance of Electrical Motors		
CO3:Describe the energy performance of Lighting System		
CO4:Explain the Energy Conservation building code, Energy Performance assessment and energy saving measures.		
CO5: Explain the process of energy audit including energy monitoring and energy management information system		
Text Books:		
1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, Guide to Energy Management, Fifth Edition, The Fairmont Press, Inc., 2006		
2. Book I - General aspect of energy management and energy audit, Second Edition 2005, By Bureau of Energy Efficiency, Ministry of Power, India.		
3. Book III - Energy efficiency in electrical utilities, Second Edition 2005, By Bureau of Energy Efficiency, Ministry of Power, India.		
References:		
1. Albert Thumann, “Handbook of Energy Audit”, Fairmont Press, 2008.		
2.Sonal Desai, “Handbook Of Energy Audit”, Mc Graw Hill India, 2015.		
3. Wayne C. Turner, “Energy management handbook”, Fairmont Press; Marcel Dekker,		

2004.

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2												
2	3	3		2	1									
3	3	3		2	1									
4	3	2		2		2	2							
5	3	2	2		2		3		2	2		1		

COURSE CODE	COURSE TITLE	L	T	P	C
UEE2041	AUTONOMOUS VEHICLES	3	0	0	3

OBJECTIVES:

- To learn the fundamental concept of autonomous electric vehicles and its driving perception techniques.
- To analyze the autonomous vehicle trajectory and routing algorithms along with its decision approaches and planning methods.
- To list the different controllers and client systems that can be employed in vehicle actuation.

Unit I INTRODUCTION TO AUTONOMOUS VEHICLE 9

Introduction to autonomous driving – Autonomous driving algorithm – fundamentals of Localisation with GNSS, LiDAR and HD maps – Visual odometry –Dead reckoning and wheel odometry – Sensor Fusion

Unit II AUTONOMOUS DRIVING PERCEPTION 9

Dataset creation – Detection – Segmentation – Stereo flow – Optical flow – Scene flow – Tracking – Deep Learning in Perception: Convolution neural networks – Application of CNN

Unit III PREDICTION AND ROUTING 9

Traffic Prediction – Vehicle Trajectory Generation – Lane Level Routing – Dijkstra routing algorithm.

Unit IV DECISION AND PLANNING 9

Decision approaches: Markov Decision Process Approach -Scenario Based Divide and Conquer Approach – Introduction to Motion Planning: Path planning, Speed Planning, Longitudinal Planning and Lateral Planning.

Unit V CONTROL AND CLIENT SYSTEM 9

Feedback Control: Bicycle model – PID Control- Basics of Client Systems – Safety, Security and Legal issues.

TOTAL PERIODS 45

COURSE OUTCOMES:

Upon successful completion of the course, students will be able to

CO1: Learn the fundamental concept of autonomous electric vehicles

CO2: Demonstrate the concept of autonomous driving perception methods.

CO3: Analyze the autonomous vehicle trajectory and routing algorithms

CO4: Explore the various decision approaches and planning methods.

CO5: Outline the controllers and client systems employed in vehicle actuation.

TEXTBOOKS:

1.Shaoshan Liu, Liyun Li, "Creating Autonomous Vehicle Systems", Morgan and Claypool Publishers, 2017.

2. Marcus Maurer, J.ChristianGerdes, "Autonomous Driving: Technical, Legal and Social Aspects" Springer, 2016.

REFERENCES:

1. Hong Cheng, "Autonomous Intelligent Vehicles: Theory, Algorithms and Implementation", Springer, 2011. 2.

2. Williams. B. Ribbens: "Understanding Automotive Electronics", 7th Edition, Elsevier Inc, 2012.

3. James Anderson, KalraNidhi, Karlyn Stanly, "Autonomous Vehicle Technology: A Guide for Policymakers", Rand Co, 2014.

4.Hong Cheng, "Autonomous Intelligent Vehicles: Theory, Algorithms and Implementation", Springer, 2011.

CO – PO MAPPING

Pos	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	3	2	2	1	1							1
CO2	3	2	2	2	2							1

CO3	3	3	3	3	2	1	1					2
CO4	3	2	1	2	3	1						1
CO5	2	2	2	2	3	1						1

COURSE CODE	COURSE TITLE	L	T	P	C
UEE2043	**ENERGY MANAGEMENT**	**3**	**0**	**0**	**3**

OBJECTIVES:

- To introduce the general aspects of energy management
- To discuss about project management and energy balance
- To explain about electrical distribution, utilisation and cogeneration

Unit I GENERAL ASPECTS 9

General Philosophy and need of Energy Management –Definition and Objective of Energy Management – General Principles of Energy Management –Energy Management Skills – Energy Management Strategy-Energy Management Approach - Understanding Energy Costs – Bench marking – Energy performance – Matching energy usage to requirements – Maximizing system efficiency – Optimizing the input energy requirements – Fuel and Energy substitution.

Unit II PROJECT MANAGEMENT 9

Definition and scope of project – technical design – financing, contracting, implementation and performance monitoring – Implementation plan for top management – Planning budget – Procurement procedures, construction – Measurements and verification

Unit III ENERGY BALANCE & MIS 9

First law of efficiency and Second law of efficiency – Facility as an Energy system – Methods for preparing process flow – Materials and Energy Balance diagram – Identification of losses, Improvements – Energy Balance sheet and Management Information System (MIS) – Energy Modeling and Optimization.

Unit IV ELECTRICAL DISTRIBUTION AND UTILISATION 9

Electrical Systems – Transformer's loss reductions – parallel operations – T & D losses – P.F. improvements – Demand Side management (DSM) – Load Management – Harmonics & its improvements – Energy efficient motors and Soft starters – Automatic power factor Controllers – Variable speed drivers – Electronic Lighting ballasts for Lighting – LED Lighting – Trends and Approaches

Unit V COGENERATION 9

Integrated analysis of steam base co-gen system – Gas turbine combine cycle operation – IC engine base co-generation and tri-generation – extraction turbines and steam cycle of cogeneration.

TOTAL PERIODS 45

COURSE OUTCOMES:

Upon successful completion of the course, students will be able to

CO1: Understand the general aspects of energy management, energy management strategy, energy management approach, energy performance and optimizing the input.

CO2: Explain the technical design, financing, contracting, budget planning and procurement procedures involved in project management.

CO3: Explain first and second law of efficiency, methods involved in preparing process flow, energy balance sheet, and modeling and optimization in management information system.

CO4: Explain demand side management, load management, power factor improvement, energy efficient motors, LED lightning and recent trends.

CO5: Explain turbine combine cycle operation, IC engine-based co-generation and tri-generation and steam cycles.

TEXTBOOKS:

1.W.R.Murphy, G.Mckay, "Energy Management: (Butterworths)".

2.W.C. Turner, "Energy Management Handbook" John Wiley and Sons, A Wiley Inter-science Publication.

3.C.B.Smith, "Energy Management Principles", Pergamon Press.

REFERENCES:

1. Energy Economics -A.V.Desai (Wieley Eastern)

2. Industrial Energy Conservation: D.A. Reay (Pergammon Press)

3.Industrial Energy Management and Utilization – L.C. Witte, P.S. Schmidt, D.R. Brown (Hemisphere Publication, Washington)

4. Industrial Energy Conservation Manuals, MIT Press, Mass, 1982

5. Energy Conservation guide book Patrick/Patrick/Fardo (Prentice Hall)

6. CIBSI Guide –User's Manual (U.K.)

7. CRC Handbook of Energy Efficiency – CRC Press.

CO – PO MAPPING

POs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**

CO1	3	3	1	1				1			3	1
CO2	3	3	1	1	2			1			3	1
CO3	3	3	1	1	2		1	1				1
CO4	3	3	1	1	2		1	1				1
CO5	3	3	1	1			1	1				1

COURSE CODE	COURSE TITLE	L	T	P	C
UEE2046	**RENEWABLE ENERGY SYSTEMS**	**3**	**0**	**0**	**3**

OBJECTIVES:

- To explain concept of various forms of renewable energy
- To introduce the division aspects and utilization of renewable energy sources for both domestics and industrial applications
- To discuss the environmental and cost economics using renewable energy sources

UNIT I INTRODUCTION 9

World energy use – Reserves of energy resources – Environmental aspects of energy utilization – Renewable energy scenario in India – Potentials – Achievements – Applications

UNIT II SOLAR ENERGY 9

Solar thermal – Flat plate and concentrating collectors – Solar heating and cooling techniques –Solar desalination – Solar cooker – Solar thermal power plant – Solar photo voltaic conversion –Solar cells – PV applications.

UNIT III WIND ENERGY 9

Wind data and energy estimation – Types of wind energy systems – Performance – Details of wind turbine generator – Safety and Environmental Aspects.

UNIT IV BIOMASS ENERGY 9

Biomass direct combustion – Biomass gasifier – Biogas plant – Ethanol production –Bio diesel –Cogeneration –Biomass applications

UNIT V OTHER RENEWABLE ENERGY SOURCES 9

Tidal energy – Wave energy – Open and closed OTEC Cycles – Small hydro – Geothermal

energy – Fuel cell systems.

TOTAL PERIODS 45

COURSE OUTCOMES:

Upon successful completion of the course, students will be able to

CO1: Explain the Environmental aspects of energy utilization and Renewable energy Scenario

CO2: Illustrate the various applications of solar energy

CO3: Discuss the concepts of types and performance of wind energy systems

CO4: Analyze the processes of biomass

CO5: Analyze the process of other possible renewable energy sources

TEXTBOOKS:

1. Rai G.D., 'Non-Conventional Energy Sources', Khanna Publishers,1999.
2. Khan B.H., 'Non-Conventional Energy Resources', Tata McGraw Hill Publishing Company Ltd., 2006.

REFERENCES:

1. Godfrey Boyle, 'Renewable Energy, Power for a Sustainable Future', Oxford UniversiPress, 1996.
2. Twidell J.W. and Weir, 'Renewable Energy Sources', EFN Spon Ltd, 1996.
3. Tiwari, 'Solar Energy – Fundamentals Design, Modelling and applications', Narosa Publishing House, 2002.
4. Freris L.L., 'Wind Energy Conversion systems', Prentice Hall, 1990.
5. Sukhatme S.P., 'Solar Energy', Tata McGraw Hill Publishing Company Ltd., 1997.

CO – PO/PSO MAPPING

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**		
1	2		1	1	1									
2	2	2	2	2	2		2					1		
3	2		2	3	2		1		1			1		
4	2		2	2	2			2						
5	2		1	1	2									

Mapping to courses – MTech. Environmental Science and Technology

Course	Sustainable Development Goals																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Biological Wastewater Treatment			✓			✓									✓		
Air Pollution and Control Engineering			✓								✓		✓		✓		
Solid and Hazardous Waste Management			✓								✓			✓			
Environmental Policies and Legislation								✓	✓							✓	
Environmental Sustainability								✓	✓		✓		✓	✓	✓	✓	
Ecology and Environment											✓			✓	✓		
Industrial Pollution Prevention								✓	✓				✓				
Environmental Impact Assessment								✓	✓				✓		✓	✓	
Wastewater Engineering			✓			✓								✓			
Marine Pollution and Control						✓								✓			
Membrane Technologies for Water and Wastewater Treatment			✓			✓									✓		
Principles of Green Chemistry and Engineering	✓				✓	✓	✓				✓		✓				
Carbon Capture and Storage							✓						✓		✓		
Climate Change and Adaptation													✓		✓		
Environmental Biotechnology								✓	✓						✓		
Soil Pollution Engineering									✓						✓		
Bioenergy conversion Techniques							✓	✓	✓								
Waste management and recovery								✓	✓						✓		
Electronic waste Management								✓	✓						✓		
Plastic Waste Management									✓		✓				✓		
Agricultural Waste Management								✓			✓				✓		
Waste to Energy							✓	✓	✓			✓			✓		

COURSE CODE	COURSE TITLE	L	T	P	C
PES2103	BIOLOGICAL WASTEWATER TREATMENT	3	0	0	3

OBJECTIVE

To educate the students on the principles and process designs of various treatment systems for water and wastewater and students should gain competency in the process employed in design of treatment systems and the components comprising such systems, leading to the selection of specific process.

UNIT I INTRODUCTION 9

Objectives of biological treatment – Significance – Types of microorganism and their role. Principles of aerobic and anaerobic treatment - Kinetics of biological growth – Factors affecting growth – Attached and suspended growth - Biodegradability assessment - Selection of process - Reactors - Batch - Continuous type.

UNIT II AEROBIC TREATMENT OF WASTEWATER 9

Design of sewage treatment plant units – Activated sludge process and variations - Sequencing batch reactors - Membrane biological reactors - Trickling filters - Bio tower -RBC - Moving bed reactors - Fluidized bed reactors - Aerated lagoons - Waste stabilization ponds – Nutrient removal systems – Natural treatment systems - Constructed wet land.

UNIT III ANAEROBIC TREATMENT OF WASTEWATER 9

Attached and suspended growth - Design of units – UASB - Up flow filters - Fluidized beds MBR - Septic tank and disposal – Nutrient removal systems – Flow chart, layout and hydraulic profile.

UNIT IV SLUDGE TREATMENT AND DISPOSAL 9

Design of sludge management facilities - Sludge thickening - Sludge digestion - Biogas generation - Sludge dewatering (mechanical and gravity) layout – Ultimate residue disposal – Recent advances.

UNIT V MODELING OF BIOREACTORS 9

Modeling suspended growth systems – Modeling microbial systems – Mass balance equation – Model for a continuous stirred tank reactor - Modeling non-ideal reactors. Bio-film modeling aerobic growth of biomass – Nature of biofilms – Transport limitations – Multiple limiting nutrients – Multispecies biofilms.

TOTAL:45 PERIODS

OUTCOMES:

On successful completion of this course, the student will be able to

CO1: Summarize the concepts and fundamentals of biological processes used in wastewater treatment
CO2: Apply the design procedures for aerobic wastewater treatment units.
CO3: Outline the design of anaerobic wastewater treatment units.
CO4: Examine the design of sludge management facilities.
CO5: Analyze the mathematical model for suspended growth and attached growth reactors.

REFERENCE BOOKS:

1. Metcalf & Eddy, INC, Wastewater Engineering – Treatment and Reuse, Fourth Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2012.
2. Arceivala, S.J., and Asolekar, S.R., Wastewater Treatment for Pollution Control and reuse McGraw Hill, third Edition, New Delhi, 2007.
3. Grady, C.P.L., Daigger, G., and Lim, H.C., Biological Wastewater Treatment, 2nd Ed, Marcel Dekker, 1999.
4. Manual on Sewerage and Sewage Treatment CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013
5. Qasim, S. R., Wastewater Treatment Plant, Planning, Design & Operation, CRC Press, New York, 2017.
6. Spellman, F.R., Handbook of Water and Wastewater Treatment Plant operations, CRC Press, New York 2009.
7. David Hendricks, Fundamentals of Water Treatment Process, CRC Press, New York 2011.

CO-PO MAPPING:

COs	**POs**			
	1	**2**	**3**	**4**
1			2	1
2	1		3	2
3	1		2	1
4	2		3	3
5	2		3	3

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
PES2201	**AIR POLLUTION AND CONTROL ENGINEERING**	**3**	**0**	**0**	**3**

OBJECTIVES

To illustrate the major problems in air pollution and control.
To describe the air pollution control measures and devices.

UNIT I INTRODUCTION 9

Introduction to Air Quality - An Overview of the Clean Air Act Amendments - Ambient Air Quality Standards in India - Properties of Air Pollutants - Sources and effects of air pollution - Emission standards - Air Quality Index.

UNIT II AIR POLLUTION MODELING 9

Meteorology and winds - Stability of the atmosphere, lapse rates & inversions - Air pollution dispersion models - Gaussian equation and other air quality models.

UNIT III INDOOR AIR QUALITY 9

Ventilation and Indoor Air Quality Control - An Overview of Indoor Air Quality - The Basics of HVAC Systems - IAQ Issues and Impacts on Occupants - IAQ Problems - Measurement and Control.

UNIT IV CONTROL OF PARTICULATE POLLUTANTS 9

Pollution Prevention - Principles of Pollution Prevention - Properties of particulate matters - Health effects of particulate pollution - Significance of PM_{10}, $PM_{2.5}$ and PM_1 - Collection mechanisms - Control of particulate matters.

UNIT V CONTROL OF GASEOUS POLLUTANTS 9

Characteristics and control of VOCs and HCs - Characteristics and control of sulphur oxides and nitrogen oxides - Control of mobile source pollutants - Global climate change.

TOTAL: 45 PERIODS

OUTCOMES

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

CO1 Summarize the air quality, properties, sources and effects of the atmospheric pollutants
CO2 Examine the meteorology and air pollution modeling
CO3 Illustrate the indoor air quality, measurement and control
CO4 Analyze the particulate pollutants and control
CO5 Outline the gaseous pollutants and control

REFERENCE BOOKS

1. Heck, R.M., and Farrauto, R.J., Catalytic Air Pollution Control: Commercial Technology, 2nd Edition John Wiley Sons, 2012

2. Nevers, N., Air Pollution Control Engineering, McGraw Hill, New York, 2011.

3. Stern, A.C., Air Pollution (Vol.I – Vol.VIII), Academic Press, 2006.

4. Wang, L.K., Parelra, N.C., Hung, Y.T., Air Pollution Control Engineering, Tokyo, 2004.

5. Anjaneyulu, Y., Air Pollution and Control Technologies, Allied Publishers (P) Ltd., India, 2002.

6. David, H.F., Liu, Bela G., Liptak Air Pollution, Lweis Publishers, 2000.

7. Davis, W.T., Air Pollution Engineering Manual, John Wiley & Sons,Inc.,2000.

CO-PO MAPPING

COs	**POs**			
	1	**2**	**3**	**4**
1		1	1	1
2	1	3	3	2
3	1	3	3	3
4	1	3	3	3
5	1	3	3	3

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
PES2203	**SOLID AND HAZARDOUS WASTE MANAGEMENT**	**3**	**0**	**0**	**3**

OBJECTIVES

To provide comprehensive overview of sources of solid and hazardous wastes.
To provide knowledge on solid and hazardous waste disposal.

UNIT I INTRODUCTION 9

Definition of solid waste - Waste generation - Sources and types of solid waste –Municipal solid wastes, radioactive waste, biomedical wastes, batteries waste, E-waste and plastics, legislations on management and handling of solid wastes.

UNIT II COLLECTION AND TRANSPORTATION 9

Collection of Solid Waste: Type of waste collection systems, analysis of collection systems. Transfer and Transport: Need for transfer operation, transport means and methods, transfer station types and design requirements.

UNIT III HAZARDOUS WASTES 9

Definition and identification of hazardous wastes - Sources and characteristics - Hazardous wastes in Municipal Waste - Hazardous waste regulations - Minimization of Hazardous Waste - Compatibility, handling and storage of hazardous waste - Collection and transport.

UNIT IV TREATMENT TECHNOLOGIES 9

Processing and transformation of solid waste: Physical and chemical treatment - Solidification, chemical fixation and encapsulation - Materials Recovery facilities, Waste transformation through combustion and anaerobic composting, anaerobic methods for materials recovery and treatment - Energy recovery - Incinerators.

UNIT V DISPOSAL OF WASTE 9

Landfills: Site selection, design and operation, drainage and leachate collection systems - Sampling and characterization of Solid Wastes; TCLP tests and leachate studies - Landfill remediation - Integrated waste management facilities.

TOTAL:45 PERIODS

OUTCOMES

On successful completion of this course, the student will be able to

CO1: Describe the various sources, types and handling of solid wastes.
CO2: Analyze the waste collection and transportation systems.
CO3: Identify the hazardous wastes and its appropriate treatment methods.
CO4: Discuss the various solid waste treatment technologies to recover energy.
CO5: Apply the various techniques for effective solid waste disposal.

REFERENCE BOOKS

1. Rao, M.N., R. Sultana, S. H. Kota,, Solid and Hazardous Waste Management: Science and Engineering,, Elsevier, Butterworth-Heinemann, 2016
2. Vesilind, P.A., Worrell, W and Reinhart, Solid waste Engineering, Thomson Learning Inc., Singapore, 2002
3. Pichtel, J.,, Waste Management Practices: Municipal, Hazardous, and Industrial, Second Edition,, CRC press , 2014
4. CPHEEO, Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organization, Government of India, New Delhi, 2000.
5. Wentz, C.A., Hazardous Waste Management, McGraw-Hill Publication, 1995.

CO-PO MAPPING

COs	POs			
	1	**2**	**3**	**4**
1		1	3	

2		1	3	
3		1	3	
4		1	3	
5		1	3	2

COURSE CODE	COURSE TITLE	L	T	P	C
PES2122	**ENVIRONMENTAL POLICIES AND LEGISLATION**	**3**	**0**	**0**	**3**

OBJECTIVES

To familiarize the students with policy and the policy formation process in each of the areas indicated below.

To provide students with substantive expertise necessary to analyze environmental policy proposals and the political considerations that produced those proposals.

UNIT I INTRODUCTION 9

Indian Constitution and Environmental Protection – National Environmental policies – Precautionary Principle and Polluter Pays Principle – Concept of absolute liability – Multilateral environmental agreements and Protocols – Montreal Protocol, Kyoto agreement, Rio declaration – Environmental Protection Act, Water (P&CP) Act, Air (P&CP) Act – Institutional framework (SPCB/CPCB/MoEF)

UNIT II WATER (P&CP) ACT, 1974 8

Power & functions of regulatory agencies - Responsibilities of Occupier Provision relating to prevention and control Scheme of Consent to establish, Consent to operate – Conditions of the consents – Outlet – Legal sampling procedures, State Water Laboratory – Appellate Authority – Penalties for violation of consent conditions etc. Provisions for closure/directions in apprehended pollution situation.

UNIT III AIR (P&CP) ACT, 1981 8

Power & functions of regulatory agencies - Responsibilities of Occupier Provision relating to prevention and control Scheme of Consent to establish, Consent to operate – Conditions of the consents – Outlet – Legal sampling procedures, State Air Laboratory - Appellate Authority- Penalties for violation of consent conditions etc., Provisions for closure/directions in apprehended pollution situation.

UNIT IV ENVIRONMENT (PROTECTION) ACT 1986 13

Genesis of the Act – Delegation of powers – Role of Central Government - EIA Notification– Sitting of Industries – Coastal Zone Regulation - Responsibilities of local bodies mitigation scheme etc., for Municipal Solid Waste Management - Responsibilities of Pollution Control Boards under Hazardous Waste rules and that of occupier, authorization– Biomedical waste rules – Responsibilities of generators and role of Pollution Control Boards

UNIT V OTHER TOPICS 7

Relevant Provisions of Indian Forest Act, Public Liability Insurance Act, CrPC, IPC -Public Interest Litigation - Writ petitions - Supreme Court Judgments in Landmark cases.

TOTAL:45 PERIODS

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

CO1: Summarize the national environmental legislation and policies.
CO2: Describe the laws and analytical techniques involved in water pollution control.
CO3: Describe the laws and analytical techniques involved in air pollution control.
CO4: Describe the Environmental Protection Act 1986.
CO5: Explain how the environmental laws are enforced.

REFERENCE BOOKS

1. Gold, D.S., Clean Air and Water Act, Marshall Cavendish Corp, 2011.
2. Tricker, R., Water Regulations in brief, Taylor & Francis, 2009.
3. Divan, S., and Roseneranz, A., Environmental law and policy in India, Oxford University Press, New Delhi, 2001.
4. CPCB, Pollution Control acts, Rules and Notifications issued there under Pollution Control Series – PCL/2/1992, Central Pollution Control Board, Delhi, 1997.
5. Megregor, G.I., Environmental law and enforcement, Lewis Publishers, London. 1994.

CO-PO MAPPING

COs	POs			
	1	**2**	**3**	**4**
1		2	2	
2		2	2	1
3		2	2	1
4		2	2	1
5		2	2	1

COURSE CODE	COURSE TITLE	L	T	P	C
PES2123	**ENVIRONMENTAL SUSTAINABILITY**	**3**	**0**	**0**	**3**

OBJECTIVE
To impact the knowledge on the concept of sustainable environment in society, the environment, and the economy.

UNIT I INTRODUCTION 9
Valuing the Environment - Concepts - Methods - Property rights - Externalities, and environmental problems.

UNIT II SUSTAINABILITY 9

Sustainable development - Defining the concept - The population problem - Natural resource economics: An overview, energy, water, agriculture.

UNIT III BIODIVERSITY & ENVIRONMENTAL PROBLEMS 9

Biodiversity - Forest habitat - Commercially valuable species - Stationary-source - Local air pollution - Acid rain and atmospheric modification - Transportation

UNIT IV ENVIRONMENTAL POLLUTION 9

Water pollution - Solid waste and recycling - Toxic substances and hazardous wastes - Global warming.

UNIT V ENVIRONMENTAL ECONOMICS 9

Development - Poverty and the Environment - Visions of the future - Environmental economics and policies.

TOTAL:45 PERIODS

OUTCOMES

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

CO1: Summarize the environment values.
CO2: Outline the concept for sustainable development for environmental systems.
CO3: Discuss the concept of biodiversity and environmental problems.
CO4: Examine different types of pollution.
CO5: Predict the environment's future vision and its economics.

REFERENCE BOOKS

1. Hoffman, A., Competitive Environmental Strategy -A Guide for the Changing Business Landscape, Island Press.
2. Doven, S., Environment and Sustainability Policy: Creation, Implementation, Evaluation, The Federation Press, 2005.
3. Vezzoli, C., and Manzini, E., Design for Environmental Sustainability, Springer Publications, 2008.
4. Maler, K.G., and Vincent, J.R., Handbook of Environmental Economics, North Holland Publications, 2005.
5. Lopez, R., and Toman, M.A., Economic development and Environmental Sustainability, Oxford University, 2006.

CO-PO MAPPING

COs	**POs**			
	1	**2**	**3**	**4**
1		2		
2		2	2	
3		2	2	
4		2	2	

5		2	2	

COURSE CODE	COURSE TITLE	L	T	P	C
PES2124	**ECOLOGY AND ENVIRONMENT**	**3**	**0**	**0**	**3**

OBJECTIVE

Students will learn about the structural and functional interactions between the ecological systems and the environment which would help in applications to the prevalent problems in the society.

UNIT I FUNDAMENTALS OF ECOLOGY 9

Aim - scope and applications of ecology, ecological engineering and eco-technology and their relevance to human civilization - Development and evolution of ecosystems - Principles and concepts pertaining to communities in ecosystem - Energy flow and material cycling in ecosystems - Productivity in ecosystems.

UNIT II ECO-TECHNOLOGY 9

Classification of eco-technology - Principles and components of systems and modeling - Structural and functional interactions in environmental systems - Human modifications of environmental systems. The ecological effects of stress - Designing sustainable ecological economic systems.

UNIT III ENERGY AND ECOSYSTEMS 9

Self-organizing processes - Multiple seeded microcosms- Interface coupling in ecological systems - Concept of energy - Adapting ecological engineering systems to potentially catastrophic events - Agro ecosystems - Determination of sustainable loading of ecosystems.

UNIT IV PRINCIPLES OF MARINE ECOSYSTEM 9

Principles and operation of soil infiltration systems - Wetlands and ponds – Source separation systems aqua cultural systems - Engineering for development in environmentally sensitive areas: Oil operations in a rain forest, detritus-based treatment for solid wastes - Applications of ecological engineering marine systems.

UNIT V APPLICATIONS 9

Ecological effects of warfare - effects of stress on ecosystem structure and function - Case studies of integrated ecological engineering systems.

TOTAL:45 PERIODS

OUTCOME

On successful completion of this course, the student will be able to

CO1: Summarize the fundamentals of ecological systems and their relation with engineering and environment.

CO2: Describe the principles in the modeling of environmental systems and design of ecological economic systems.

CO3: Demonstrate engineering studies based on ecological criteria.
CO4: Describe the principles and applications in the marine ecosystem.
CO5: Apply the concept to find the solutions to problems pertaining to environmental issues.

REFERENCE BOOKS

1 IgnaciMuthu, S., Ecology and Environment, Eastern Book Corporation, 2007.
2 Krebs, Charles, J., Ecology: The Experimental Analysis of Distribution and Abundance. 5th edition, 2001.
3 Mitsch, J.W., and Jorgensen, S.E., Ecological Engineering, An Introduction to Ecotechnology, John Wiley & Sons, New York, 1989.
4 Kumar De, A., Environment and Ecology, New Age International Private Limited, 2009.
5 Ehrlich, P. R., and Ehrlich, A.H., Population, Resources, Environment: Issues in Human Ecology, 1972.
6 Engineering within ecological Constraints, Edited by Peter C. Schulze, National academy of engineering national academy press Washington, D.C. 1996
7 Environmental Ecology, 1st Edition by Bill Freedman, Academic Press, 1989.
8 Ecology and Environment, 1st Edition. R.N Bhargava, V. Rajaram, Keith Olson, Lynn Tiede, CRC press, 2018.

CO-PO MAPPING

COs	**POs**			
	1	**2**	**3**	**4**
1			2	
2			2	1
3			3	2
4	1		2	
5			3	

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
PES2125	**INDUSTRIAL POLLUTION PREVENTION**	**3**	**0**	**0**	**3**

OBJECTIVES

- To provide knowledge on sources and characteristics of industrial pollution, techniques and approaches for minimizing the generation of pollutants.
- Application of physio-chemical and biological treatment methods for recovery, reuse and disposal supported with case studies under Indian situations.

UNIT I ENVIRONMENTAL LAWS 9

Basics of Jurisprudence-Environmental law relation with other disciplines-Criminal law-Common law-Relevant sections of the code of civil procedure, criminal procedure code - Indian Penal code.

UNIT II FUNDAMENTAL POLICIES 9

Fundamental Rights - Directive principles of state policy - Article 48(A) and 51-A (g) Judicial enforceability - Constitution and resources management and pollution control-Indian forest policy (1990) – Indian Environmental policy (1992).

UNIT III POLLUTION ABATEMENT REGULATIONS 9

Administration regulations - Constitution of pollution control boards powers - Functions - Accounts - Audit etc. - Formal Justice Delivery Mechanism Higher and Lower of judiciary - Constitutional remedies - Writ jurisdiction Article 32,226,136 special reference to mandamus and certiorari for pollution abatement - Equitable remedies for pollution control.

UNIT IV WATER & AIR ACT 9

Administrative regulation under recent legislations in water pollution control - Water (prevention and control of pollution) Act 1974 as Amended by amendment act 1988 - Water (prevention of control and pollution) Rules1975 - Water (prevention and pollution) Cess Act.1977 as amended by amendment act1991 - Air(prevention and control of pollution) Act 1981 as amended by Amendment act 1987 and relevant notifications.

UNIT V MANAGEMENT AND WASTE HANDLING 9

Relevant notifications in connection with Hazardous Wastes (management and handling) - Biomedical Wastes (Management and Handling) - Noise pollution - Eco-labelling and EIA.

TOTAL: 45 PERIODS

OUTCOMES

On successful completion of this course, the student will be able to

CO1: Summarize the environmental laws with penal code.
CO2: Describe the fundamental rights and act.
CO3: Apply the pollution abatement regulations to industries.
CO4: Outline the water & air act.
CO5**:** Analyze the best management and waste handling techniques.

REFERENCE BOOKS

1. Constitution of India Eastern Book Company, Lucknow, 12th Edition, 1997.
2. Pandey, J.N., Constitutional Law of India, (31st Edition) Central Law of Agency, Allahabad, 1997.
3. Kesari, U.P.D., Administrative Law, Universal Book Trade, Delhi, 1998.
4. Tiwari, H.N., Environmental Law, Allahabad Law Agency 1997.
5. Divan, S., and Roseneranz, A., Environmental law and policy in India, Oxford University Press, New Delhi, 2001.

CO-PO MAPPING

COs	POs			
	1	2	3	4
1			2	2
2			2	2
3			3	2
4			2	2
5			2	2

COURSE CODE	COURSE TITLE	L	T	P	C
PES2222	ENVIRONMENTAL IMPACT ASSESSMENT	3	0	0	3

OBJECTIVE

To protect the environment from various developmental projects or activity by providing alternative solutions.

UNIT I INTRODUCTION 9

Environmental Impact Assessment (EIA) -Environmental Impact Statement (EIS), Environmental Risk Assessment (ERA) - Legal and regulatory aspects in India - Types and limitations of EIA - Terms of Reference in EIA- Issues in EIA - National – Cross-Sectoral - Social and Cultural.

UNIT II EIA METHODOLOGIES 9

Screening and scoping in EIA - Criteria for selection of methods – Adhoc – Check list – Matrix – Network – Overlay – Cost/Benefit Analysis – Mathematical models for impact prediction.

UNIT III APPLICATION OF REMOTE SENSING AND GIS IN EIA 9

Introduction – Principles of Remote sensing – Linear Projects – Coastal Zone studies – Estuaries – GIS for Environmental Impact Assessment – Databases and major applications of GIS.

UNIT IV PREDICTION AND MITIGATION MEASURES 9

Prediction and assessment of impacts - Air - Water - Soil - Noise - Biological - Cultural - Social - Economic environments. Standards and guidelines for evaluation- EIA report preparation- Public participation in environmental decision-making.

UNIT V CASE STUDIES 9

Case studies of EIA of developmental projects in Food, Fertilizer and Petrochemical industry.

TOTAL: 45 PERIODS

OUTCOMES

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

CO1: Perceive the importance of Environmental Impact Assessment and the issues in EIA
CO2: Calculate the Environmental impacts by applying different EIA methods

CO3: Interpret the importance of environmental monitoring using Remote sensing and GIS
CO4: Predict the impacts for various environment and its mitigation measures
CO5: Apply the concept of EIA on various developmental projects

REFERENCE BOOKS

1. Anji Reddy Mareddy., Environmental Impact Assessment Theory and Practice, 1st Edition, Butterworth-Heinemann, 2017.
2. Riki Therivel and Graham Wood, Methods of Environmental Impact and Social Assessment,4th Edition, Routledge, 2017.
3. Anjaneyulu, Y., and Manickam, V., Environmental Impact Assessment, Methodologies, 2nd Edition, CRC press, BS Publications, 2011
4. Petts, J., Handbook of Environmental Impact Assessment Vol. I and II, Blackwell Science, London, 2009.
5. Lawrence, D.P., Environmental Impact Assessment – Practical solutions to recurrent problems, Wiley-Interscience, New Jersey, 2003.

CO-PO MAPPING

COs	**POs**			
	1	**2**	**3**	**4**
1		2	2	1
2			3	2
3	2			2
4	2		3	2
5	2		3	2

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
PES2224	**WASTEWATER ENGINEERING**	**3**	**0**	**0**	**3**

OBJECTIVES
To learn about the different types of wastewater treatment methods.
To understand the design of the wastewater treatment units.

UNIT I INTRODUCTION 9
Industrial scenario - Uses of water by industry - Sources and types of industrial wastewater – Industrial wastewater disposal and environmental impacts - Reasons for treatment of industrial wastewater – Regulatory requirements - Industrial waste survey - Industrial wastewater generation rates, characterization and variables – Population equivalent - Toxicity of industrial effluents and Bioassay tests - Preventing and minimizing wastes at the source - Individual and Common Effluent Treatment Plants - Joint treatment of industrial wastewater.

UNIT II INDUSTRIAL WASTEWATER TREATMENT 9

Equalization - Neutralization - Oil separation - Flotation - Precipitation - Heavy metal Removal – Refractory organics separation by adsorption - Aerobic and anaerobic biological treatment - Sequencing batch reactors – High rate reactors.

UNIT III ADVANCED WASTEWATER TREATMENT AND REUSE 9

Chemical oxidation - Ozonation - Photocatalysis - Wet Air Oxidation - Evaporation – Ion Exchange – Membrane Technologies - Nutrient removal - Land Treatment.

UNIT IV RESIDUALS MANAGEMENT 9

Residuals of industrial wastewater treatment - Quantification and characteristics of Sludge - Thickening, digestion, conditioning, dewatering and disposal of sludge - Management of RO rejects.

UNIT V CASE STUDIES 9

Industrial manufacturing process description, wastewater characteristics and waste treatment flow sheet for Textiles - Tanneries - Pulp and paper - metal finishing – Petroleum Refining - Chemical industries - Sugar and Distilleries - Dairy - Iron and steel - fertilizers - Industrial clusters and Industrial Estates.

TOTAL: 45 PERIODS

OUTCOMES

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

CO 1: Summarize the general scenario of industrial wastewater generation and their regulatory requirement.
CO 2: Examine the various industrial waste water treatment techniques.
CO 3: Categorize the various advanced industrial waste water treatment techniques
CO 4: Outline the residuals management of industrial wastewater
CO 5: Apply greater insight about industrial manufacturing process through various case studies promote environmentally sound and sustainable development by identifying appropriate measures.

REFERENCE BOOKS

1. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017.
2. Nemerow, N.L., Industrial waste treatment - Contemporary practice and vision for the future. Elsevier, Singapore. 2007.
3. Jern, N.W., Industrial wastewater treatment, World Scientific Publications, 2006.
4. Eckenfelder, W. W., Industrial Water Pollution Control, Mc-Graw Hill, 1999.
5. Arceivala, S. J., Wastewater Treatment for Pollution Control, Tata McGraw Hill, 1998.
6. Pollution Prevention and Abatement Handbook – Towards Cleaner Production, World Bank and UNEP, Washington, 1998.

CO-PO MAPPING

COs	POs

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1			2	
2			3	1
3			3	1
4			3	1
5			3	1

COURSE CODE	COURSE TITLE	L	T	P	C
PES2225	MARINE POLLUTION AND CONTROL	3	0	0	3

OBJECTIVE

To impart the knowledge about marine and coastal environment, oceanography, and sources, effects and monitoring of marine pollutants.

UNIT I MARINE AND COASTAL ENVIRONMENT 9

Seas and oceans, continental area, coastal zone, properties of sea water, principles of marine geology, coastal features – Beaches, estuaries, lagoons, salt marshes, mangroves and sand dunes – The oceans and climate, coastal zone regulation in India - National and international treaties.

UNIT II OCEAN HYDRODYNAMICS 9

Wave theory, waves in shallow waters – Refraction, diffraction and shoaling, approximations for deep and shallow water conditions – Tidal classification - General circulation of ocean waters - Ocean currents - Coastal sediment transport - Onshore and offshore sediment transport - Beach formation and coastal processes - Tsunamis, storm surge, El Nino effect.

UNIT III MARINE POLLUTION SOURCES 9

Sources of marine pollution – Point and non-point sources, pollution caused by effluent discharge, oil exploration, dredging, offshore mining, port and harbour activities, power plants, agriculture runoff, plastic waste, marine debris and marine litter - Effects of marine pollution on marine water quality and coastal ecosystems.

UNIT IV MARINE POLLUTION MONITORING 9

Basic measurements - Sounding boat, echo sounders – Current meters - Tide gauge - Use of GPS – Measurement of coastal water characteristics – Sea bed sampling – Modeling of pollutant transport and dispersion - Oil spill models - Ocean monitoring satellites – Applications of remote sensing and GIS in monitoring marine pollution – Online marine pollution monitoring.

UNIT V MARINE POLLUTION CONTROL MEASURES 9

Marine discharges and effluent standards, pollution control strategies – Marine outfall design selection of optimal marine outfall locations - Total Maximum Daily Load (TMDL) applications

– Protocols in marine pollution control– Integrated Coastal Zone Management (ICZM) and sustainable development.

TOTAL:45 PERIODS

OUTCOMES

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

CO1: Summarize the different components of marine and coastal environment.
CO2: Interpret the physical concepts lying behind the tides, waves, and oceanic currents and natural processes of various activities happening over the marine environment.
CO3: Identify and measure the marine pollution levels and effects.
CO4: Apply the knowledge of remote sensing and GIS for monitoring marine environment water quality.
CO5: Outline the various marine pollution control measures.

REFERENCE BOOKS

1. Senthil Kumar, P., Modern Treatment Strategies for Marine Pollution, Elsevier, 2021.
2. Hofer, T.N., Marine Pollution: New Research, Nova Publishers, 2018.
3. Clark, R.B., Frid, C., Atttrill, M., Marine Pollution, Oxford Science Publications, 5th Edition, 2017.
4. Laws, E.A., Aquatic pollution, an introductory text. John Wiley and Sons, Inc., New York, 2000.
5. Sinha, P.C., Marine pollution, Anmol Publications Pvt. Ltd, 1998.
6. Kennish, M.J., Practical Handbook of Estuarine and Marine Pollution, Volume 10 of CRC Marine Science, CRC Press, 1996.

CO-PO MAPPING

COs	**POs**			
	1	**2**	**3**	**4**
1			2	1
2		3	3	
3			3	1
4			3	2
5			3	3

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
PES2226	**MEMBRANE TECHNOLOGIES FOR WATER AND WASTEWATER TREATMENT**	**3**	**0**	**0**	**3**

OBJECTIVE

To make students understand about the principles behind separation systems, membrane processes and systems, membrane bioreactors and pre-treatment systems.

UNIT I INTRODUCTION 10

Solid Liquid separation systems- Filtration systems - Theory of membrane separation – Mass transport characteristics - Cross flow filtration - Membrane filtration- Types and choice of membranes, porous, non-porous, symmetric and asymmetric – Plate and Frame, spiral wound and hollow fiber membranes – Liquid membranes.

UNIT II MEMBRANE PROCESSES AND SYSTEMS 10

Microfiltration – Ultrafiltration - Nano Filtration – Reverse Osmosis – Electrodialysis - Pervaporation Membrane Module/Element designs – Membrane system components – Design of membrane systems - Pump types and pump selection – Plant operations.

UNIT III MEMBRANE BIOREACTORS 9

Introduction and historical perspective of MBRs - Biotreatment fundamentals - Membrane bioreactor technology – MBR configurations - Elements of an immersed biomass-rejection MBR - MBR Design Principles and Operation - Alternative MBR Configurations.

UNIT IV PRETREATMENT SYSTEMS 8

Membrane Fouling – Pre-treatment methods and strategies – Monitoring of pre-treatment – Langlier Index, Silt Density Index - Chemical cleaning - Biofouling control.

UNIT V CASE STUDIES 8

Commercial technologies - Case studies on the design of membrane-based water and wastewater treatment systems – Zero liquid effluent discharge plants.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1: Summarize the principle and working of filtration using different types of membrane modules.
CO2: Describe the design principles of membrane systems for various industrial applications.
CO3: Examine the membrane bioreactor for treating industrial wastewater.
CO4: Outline the pre-treatment methods and strategies followed to control membrane fouling.
CO5: Apply the principles involved in membrane-based systems for water and wastewater treatment.

REFERENCE BOOKS

1. Jud, S., MBR Book – Principles and application of MBR in water and wastewater treatment, Elservier, 2006.
2. McGraw-Hill, Water Environment Federation (WEF), Membrane Systems for Wastewater Treatment, USA, 2005.
3. Wagner, J., Membrane Filtration handbook, Practical Tips and Hints, Second Edition, Revision 2, Osmonics Inc., 2001.

4. Yamamoto, K., and Urase, T., Membrane Technology in Environmental management, special issue, Water Science and technology, Vol.41, IWA Publishing, 2000.
5. Mulder, M., Basic Principle of Membrane Technology, Kluwer Academic Publishers, 1996
6. Noble, R.D., and Stern, S.A., Membrane Separations Technology: Principles and Applications, Elsevier, 1995.

CO-PO MAPPING

COs	POs			
	1	**2**	**3**	**4**
1		2	2	1
2		2	2	1
3	2	3	3	3
4		2	2	1
5	1	3	3	2

COURSE CODE	COURSE TITLE	L	T	P	C
PES2231	**PRINCIPLES OF GREEN CHEMISTRY AND ENGINEERING**	**3**	**0**	**0**	**3**

OBJECTIVE

To make students aware of global environmental issues, concepts behind pollution prevention, environmental risks, green chemistry, methods to evaluate environmental costs and life cycle assessments.

UNIT I OVERVIEW OF ENVIRONMENTAL ISSUES 9

Global environmental issues - Air quality issues - Water quality issues - Ecology - Natural resources - Description of risk - Value of risk assessment in the engineering profession - Risk-based environmental law - Risk assessment concepts - Hazard assessment - Dose-response - Risk characterization.

UNIT II POLLUTION PREVENTION 9

Pollution prevention concepts and terminology - Chemical process safety - Responsibilities for environmental protection - Environmental persistence - Classifying environmental risks based on chemical structure - Exposure assessment for chemicals in the ambient environment.

UNIT III GREEN CHEMISTRY 9

Green chemistry methodologies - Quantitative/optimization-based frameworks for the design of green chemical synthesis pathways - Green chemistry pollution prevention in material selection for unit operations - Pollution prevention for chemical reactors - Pollution prevention for separation devices - Pollution prevention applications for separative reactors - Pollution prevention in storage tanks and fugitive sources.

UNIT IV PROCESS INTEGRATION AND INTENSIFICATION 9

Process energy integration - Process mass integration-Process Intensification - Case study of a process flow sheet - Estimation of environmental fates of emissions and wastes.

UNIT V LIFE CYCLE ASSESSMENT 9

Magnitudes of environmental costs - A framework for evaluating environmental costs - Hidden environmental costs - Liability costs - Internal intangible costs - External intangible costs - Introduction to product life cycle concepts - Life-cycle assessment - Life-cycle impact assessments - Streamlined life-cycle assessments - Uses of life-cycle studies.

TOTAL: 45 PERIODS

OUTCOMES

On successful completion of this course, the student will be able to

CO1: Summarize the global environmental issues and risk assessment techniques.
CO2: Discuss the pollution prevention-based concepts and terminology.
CO3: Apply the green chemistry principles and methodologies towards best pollution preventions.
CO4: Analyze the process energy integration methods towards the minimization of emissions and waste.
CO5: Describe the cost analysis and life cycle assessment techniques.

REFERENCE BOOKS

1. M. Lancaster, "Green Chemistry: An Introductory Text, Royal Society of Chemistry, Edition 3, 2016.
2. P. Anastas and P. Trevorrow, Handbook of Green Chemistry, Green Processes, Designing Safer Chemicals, 2013, ISBN 3527326391.
3. J. H. Clark, A. Hunt, C. Topi, G. Paggiola and J. Sherwood, Sustainable Solvents: Perspectives from Research, Business and International Policy (Green Chemistry Series), 2017, ISBN 1782623353.

CO-PO MAPPING

COs	**POs**			
	1	**2**	**3**	**4**
1			2	1
2			2	1
3			3	1
4			3	1
5			2	1

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
PES2321	**CARBON CAPTURE AND STORAGE**	**3**	**0**	**0**	**3**

OBJECTIVE

To impact knowledge in the field of carbon capture and storage technologies and also deals with CO_2 conversion, utilization and storage.

UNIT I INTRODUCTION TO CCS 9

What is CCS; Physical and chemical properties of fluids - Pure CO_2 and mixtures; Sources of emission; Indian & Global Scenario in CO_2 emission; need for CCS; Methods for CCS - Pre-combustion, Post-combustion and Oxy-fuel combustion; Advancement in CCS research - Indian & Global Scenario; Existing CCS technology - Merits and demerits.

Carbon Trading; Mechanisms - Main Types– Global Status in Carbon Trading. Carbon Footprint Calculation–Direct, Indirect and Others Indirect Sources of Green House Gas Emissions.

UNIT II SOLVENT-BASED CCS TECHNOLOGY 9

Carbonate-based CO_2 Absorption; Amine-based CCS Technology; Ammonia-based CO_2 capture and amine blends; Phase-change solvents; Deep-eutectic solvents; Cryogenic separation; Solvent-regeneration/CO_2 stripping technology.

UNIT III SORBENT AND MEMBRANE TECHNOLOGY 9

Carbon-based sorbents: Polymer supported capture agents; Pressure swing adsorption technologies; Metal Organic Frame Works (MOFs); Membrane Technology.

UNIT IV BIOLOGICAL METHOD OF CCS TECHNOLOGY 9

Oceanic fertilization; Terrestrial sequestration - Soil-carbon sequestration - Phyto-sequestration; Enzyme-based Carbon Capture.

UNIT V CO_2 CONVERSION, UTILIZATION AND STORAGE 9

Conversion - Photo and electro catalytic conversion - Biological conversion. Utilization - Extractant - Mineralization - Chemicals - Refrigerants - Inerting agents - Fire suppression - Plastics - Enhanced fuel recovery - Food/Products. Geologic storage - Depleted oil and gas fields - Deep saline formations - Un-mineable coal seams - Basalt formations. Health, safety and environmental issues associated with CO_2 storage.

TOTAL:45 PERIODS

OUTCOMES

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

CO1: Describe the importance and challenges in the CCS process.
CO2: Examine the novel solvents and its regeneration techniques for CCS process.
CO3: Articulate the novel sorbents and membranes for CCS process.
CO4: Categorize the biological methods of CCS process.
CO5: Devise the suitable CO_2 conversion, utilization, and storage techniques.

REFERENCE BOOKS

1. Stephen A. R., Carbon Capture and Storage, Elsevier, 2nd Edition, 2017.
2. Fan S and Bryan M., Novel Materials for Carbon Dioxide Mitigation Technology, Elsevier, 1st Edition, 2015.
3. Wilhelm K., Jürgen F. H., Carbon Capture, Storage and Use, Springer, 2015.

4. Ronald E. Hester, Roy M. Harrison, Carbon Capture: Sequestration and Storage (Issues in Environmental Science and Technology), Royal Society of Chemistry, 1st Edition, 2009.
5. Martin M. H., and Meyer S., Greenhouse Gas Carbon Dioxide Mitigation: Science and Technology, CRC Press,1st Edition, 1998.

CO-PO MAPPING

COs	POs			
	1	**2**	**3**	**4**
1	1	3	3	
2	1	3	3	
3	1	3	3	
4		3	3	
5		3	3	

COURSE CODE	COURSE TITLE	L	T	P	C
PES2322	**CLIMATE CHANGE AND ADAPTATION**	**3**	**0**	**0**	**3**

OBJECTIVE

To understand the Earth's Climate System and the concept of Global Warming and impact on society and its mitigation measures.

UNIT I EARTH'S CLIMATE SYSTEM 9

Introduction-Climate in the spotlight - The Earth's Climate Machine – Climate classification - Global Wind Systems – Trade Winds and the Hadley Cell – The Westerlies - Cloud formation and monsoon rains – Storms and Hurricanes - The Hydrological Cycle – Global ocean circulation – El Nino and its effect - Solar radiation –The Earth's Natural Green House Effect – Green house gases and global warming – Carbon cycle.

UNIT II OBSERVED CHANGES AND ITS CAUSES 9

Observation of climate change – Changes in patterns of temperature, precipitation and sea level rise – Observed effects of climate changes – Patterns of large scale variability – Drivers of climate change – Climate sensitivity and feedbacks – The Montreal Protocol – UNFCCC – IPCC – Evidences of changes in climate and environment – on a Global Scale and in India – climate change modeling**.**

UNIT III IMPACTS OF CLIMATE CHANGE 9

Impacts of climate change on various sectors – Agriculture, Forestry and Ecosystem – Water resources – Human health – Industry, settlement and society – Methods and Scenarios – Projected impacts for different regions– Uncertainties in the projected impacts of climate change – Risk of irreversible changes.

UNIT IV CLIMATE CHANGE ADAPTATION AND MITIGATION MEASURES 9

Adaptation Strategy/Options in various sectors – Water – Agriculture –- Infrastructure and settlement including coastal zones – Human health – Tourism – Transport – Energy – Key mitigation technologies and practices – Energy supply – Transport – Buildings – Industry – Agriculture – Forestry - Carbon sequestration – Carbon capture and storage (CCS)- Waste (MSW & Bio waste, Biomedical, Industrial waste) – International and regional cooperation.

UNIT V CLEAN TECHNOLOGY AND ENERGY 9

Clean development mechanism –Carbon trading- examples of future clean technology – Biodiesel – Natural compost – Eco- friendly plastic – Alternate energy – Hydrogen – Bio-fuels – Solar energy – Wind – Hydroelectric power – Mitigation efforts in India and adaptation funding.

TOTAL:45 PERIODS

OUTCOMES

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

CO1: Discuss the Earth's climate system.
CO2: Illustrate climate changes and its causes.
CO3: Summarize the impacts of climate change on various sectors.
CO4: Articulate the climate change adaptation and mitigation strategies in various sectors.
CO5: Examine the clean and renewable energy technology.

REFERENCE BOOKS

1. Jan C. van Dam, Impacts of Climate Change and Climate Variability on Hydrological Regimes, Cambridge University Press, 2003.
2. Kumar, D.S., Climate Change – An Indian Perspective, Cambridge University Press India Pvt. Ltd, 2007.
3. Letcher, T., Climate change: Observed impacts on planet Earth, Elsevier Publications, 2009.
4. Mark, Z. J., 100% Clean, Renewable Energy and Storage for Everything, Cambridge University Press, 2020.
5. Robert, F., The Handbook of Global Climate and Environment Policy, John Wiley & Sons, 2013.

CO-PO MAPPING

COs	POs			
	1	**2**	**3**	**4**
1		2		
2		2	2	
3		2	2	
4		3	3	
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COURSE CODE	COURSE TITLE	L	T	P	C

PES2323	ENVIRONMENTAL BIOTECHNOLOGY	3	0	0	3

OBJECTIVE

The main objective of this course is to impart students an understanding of pollution of environment by air, water and soil responsible for degradation of natural resources and degradation of biodiversity.

UNIT I MICROBES AND METABOLISM 9

Definitions, concept, scope and application of biotechnology - Genetically engineered organisms – Merits and demerits. Microbes in the service of mankind - Microbial remediation of contaminated lands and water - Microbes in the management of waste water - Microbial composting of solid wastes - Metabolic pathways of particular relevance to environmental biotechnology - Production of cellular - Fermentation and respiration.

UNIT II POLLUTION CONTROL 9

Classification of pollutants - Pollution control strategies - Practical toxicity issues - Practical applications to pollution control - Bio filters - Bio trickling filters - Advances in biogas technology - Bio scrubbers and other options - Process changes in different pollutants generating industries.

UNIT III BIOREMEDIATION 9

Bioremediation: Remediation methods - Techniques - Suitability of bioremediation - Factors affecting bioremediation - Technical, economic, and regulatory future for bioremediation - An industry perspective - Biodegradation of solid wastes - Selection of environmental biotechnology viable in field-scale waste treatment applications. Bio fertilizers, Vermiculture Biotechnology: Vermiculture for sustainable agriculture and solid waste management.

UNIT IV BIOTECHNOLOGICAL REMEDIES 9

Biotechnological remedies for environmental damages - Decontamination of ground water systems – Subsurface environment - Reclamation concepts. Degradation of high concentrated toxic pollutants - non-halogenated, halogenated - Petroleum hydrocarbons - Metals. Mechanisms of detoxification - Oxidation reactions - Dehalogenation - Biotransformation of metals. Microbial cell/enzyme technology – Adapted microorganisms - Biological removal of nutrients – Microalgal biotechnology.

UNIT V BIOTECHNOLOGY VALUE ADDITION AND ENVIRONMENTAL MONITORING 9

Production of value added products from waste – Single Cell Protein (SCP), ethanol, methane and hydrogen, amino acids, vitamins - Enzyme production from wastes – Biodegradable plastics - Environmental implications. Bioindicators – Biomarkers –Biosensors – Biomonitoring – Polluted environment – Short- and long-term monitoring of remediated sites.

TOTAL: 45 PERIODS

OUTCOMES

On successful completion of this course, the student will be able to

CO1: Apply the concept of environmental biotechnology and the different types of microbes used.

CO2: Describe the different pollutants and identify the appropriate control strategy.
CO3: Examine the nature of solid waste pollutants and recognize their remediation through environmental biotechnology techniques.
CO4: Summarize the biotechnological strategies for decontamination and detoxification of environmental systems
CO5: Outline the knowledge on producing value added products and environmental monitoring.

REFERENCES

1. Fulker M.H. Environmental Biotechnology, CRC Press, 2010.
2. Chatterji. A.K., 2003. Introduction to Environmental Biotechnology. Prentice Hall of India Pvt. Ltd., New Delhi.
3. Miller Jr. G. T., 2004. Environmental Science. Tenth Edition. Thompson Brooks/Cole. United States.
4. Wainwright, M, An Introduction to Environmental Biotechnology, 1999.
5. Martin, A.M., Biological Degradation of Wastes, Elsevier Appl. Science, New York,1991

CO-PO MAPPING

COs	**POs**			
	1	**2**	**3**	**4**
1	2		3	
2	1		2	
3	2		3	
4	1		2	
5	1		2	

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
PES2325	**SOIL POLLUTION ENGINEERING**	3	0	0	3

OBJECTIVES

To learn the characteristics of the soil and to learn the contaminants transport in the soil
To learn the soil pollution controlling techniques.

UNIT I PHYSICS AND CHEMISTRY OF SOIL 9

Soil formation – Composition – Soil fabric – Mass-volume relationship – Index properties and soil classification – Hydraulic and consolidation characteristics – Chemical properties – Soil pH – Surface charge and point of zero charge – Anion and Cation exchange capacity of clays – Specific surface area - Bonding in clays-soil pollution - Factors governing soil pollutant interaction.

UNIT II INORGANIC AND ORGANIC GEOCHEMISTRY 9

Inorganic geochemistry – Metal contamination – Distribution of metals in soils Geochemical processes controlling the distribution of metals in soils – Chemical analysis of metal in soil – Organic geochemistry – Organic contamination – Distribution of NAPLs in soils – Process controlling the distribution of NAPLs in soil – Chemical analysis of NAPLs in soils.

UNIT III CONTAMINANT FATE AND TRANSPORT IN SOIL 9

Transport processes – Advection – Diffusion – Dispersion – Chemical mass transfer processes – Sorption and desorption – Precipitation and dissolution – Oxidation and reduction – Acid base reaction – Complexation – Ion exchange – Volatilization – Hydrolysis – Biological process - Microbial transformation of heavy metals.

UNIT IV GROUND IMPROVEMENT TECHNIQUES IN WASTE MANAGEMENT 9

Role of Ground Improvement-Drainage and Ground Water Lowering-Electro osmotic Methods-Diaphragm walls-Thermal and Freezing methods - Insitu Densification – Deep Compaction - Dynamic Compaction - Blasting Sand piles pre-loading with sand drains- Stone Columns Lime piles - Earth reinforcement - Rock bolts Cables and guniting Geotextiles as reinforcement Filtration - Drainage and Erosion control.

UNIT V SOIL REMEDIATION TECHNOLOGIES 9

Contaminated site characterization – Containment – Soil vapour extraction - Soil washing – Solidification and Stabilization – Electro-kinetic remediation – Thermal desorption Vitrification – In-situ and Ex-situ Bioremediation – Phytoremediation – Soil fracturing – Biostimulation – Bioaugmentation – Chemical oxidation and reduction.

TOTAL: 45 PERIODS

OUTCOMES

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

CO 1: Summarize the physics and chemistry of soils.
CO 2: Indicate inorganic and organic geochemistry
CO 3: Show the contaminant fate and trasport in soil
CO 4: Predict the ground improvement techniques in waste management
CO 5: Analyze the different kinds of soil remediation techniques.

REFERENCE BOOKS

1. Perk, M.V., Soil and Water Contamination from Molecular to Catchment Scale, Taylor & Francis, 2006.
2. Rose, C., An Introduction to the Environmental Physics of Soil, Water and Water Sheds, Cambridge University Press, 2004.
3. Nathanail, P.C., and Bardos, P.R., Reclamation of Contaminated Land, John Wiley& Sons Limited, 2004.
4. Sharma, H.D., and Reddy, K.R., Geo-Environmental Engineering: Site Remediation, Water Contaminant and Emerging Water Management Technologies, John Wiley & Sons Limited, 2004.
5. Deutsch, W.J., Groundwater Geochemistry: Fundamentals and Applications to Contamination, Lewis Publishers, 1997.

CO-PO MAPPING

COs	POs			
	1	2	3	4
1			2	
2			3	
3			3	2
4			3	2
5			3	2

COURSE CODE	COURSE TITLE	L	T	P	C
PES2326	BIO-ENERGY CONVERSION TECHNIQUES	3	0	0	3

OBJECTIVES

To learn the different kinds of feed stocks for energy generation.
To learn the different kinds of energy conservation techniques.

UNIT I INTRODUCTION 9

Biomass: types – advantages and drawbacks – Indian and Global scenario – Characteristics – Carbon neutrality – Energy conversion methods overview. Fuel assessment studies – Thermo-gravimetric analysis – Differential thermal analysis – Differential scanning calorimetry

UNIT II BIOMETHANATION 9

Microbial systems – Phases in biogas production – Parameters affecting gas production – Effect of additives on biogas yield – Possible feed stocks. Biogas plants – Types – Design – Constructional details and comparison – Biogas application – for heating, lighting and power generation – Effect on engine performance.

UNIT III COMBUSTION 9

Densification of biomass, briquetting process – Merits and demerits of densification – Feed requirements and pre-processing. Perfect, complete and incomplete combustion – Equivalence ratio – Fixed Bed, fluidized bed systems– Fuel and ash handling – Steam cost comparison with conventional fuels, co-firing of biomass with coal.

UNIT IV GASIFICATION, PYROLYSIS AND CARBONIZATION 9

Fixed bed and fluidized bed gasifiers, comparison – Application engine characteristics – Gas cooling and cleaning system. Pyrolysis - Classification - Process governing parameters – Typical yield rates. Carbonization techniques – Merits of carbonized fuels

UNIT V BIOFUELS 9

Suitable feedstocks, production methods, usage with conventional petroleum fuels. Biodiesel production from oil seeds, waste oils and algae - Process and chemistry - Biodiesel health effects / emissions / performance. Production of alcoholic fuels (methanol and ethanol) from biomass – engine modifications-Biohydrogen.

TOTAL: 45 PERIODS

OUTCOMES

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

CO1: Estimate the availability and characterisation of biomass for energy applications.

CO2: Describe the key aspects of bio-methanation process.

CO3: Summarize the key aspects of biomass combustion aspects.

CO4: Use the techniques of biomass gasification, pyrolysis, and carbonization.

CO5: Predict the suitable feedstocks and conversion methods and usage of bioethanol and biodiesel.

REFERENCE BOOKS

1. Pratima Bajpai, Biomass to Energy Conversion Technologies, Elsevier, 2019
2. Sergio C. Capareda, Introduction to Biomass Energy Conversion, CRC Press, 2014
3. Donald L. Klass, Biomass for Renewable Energy, Fuels, and Chemicals, Academic Press, 1998.

CO-PO MAPPING

COs	POs			
	1	2	3	4
1			3	
2			2	
3			3	
4			2	
5		2	3	

COURSE CODE	COURSE TITLE	L	T	P	C
PES2327	WASTE MANAGEMENT AND ENERGY RECOVERY	3	0	0	3

OBJECTIVES

To understand the comprehensive overview of solid and hazardous waste management.

To gain the knowledge on solid waste management design aspects.

To learn the energy generation process from the solid waste management units.

UNIT I SOLID WASTE – CHARACTERISTICS AND PERSPECTIVES 8

Definition - Types – Sources – Generation and estimation. Properties: physical, chemical and biological – Regulation

UNIT II COLLECTION, TRANSPORTATION AND PROCESSING TECHNIQUES 9

Onsite handling, storage and processing – Types of waste collection mechanisms - Transfer stations : types and location – Manual component separation - Volume reduction : mechanical, thermal – separation : Mechanical, magnetic electro mechanical.

UNIT III ENERGY GENERATION TECHNIQUES 10

Basics, types, working and typical conversion efficiencies of composting – Anaerobic digestion – RDF – Combustion – Incineration – Gasification – Pyrolysis - Carbonization.

UNIT IV HAZARDOUS WASTE MANAGEMENT 9

Hazardous waste – Definition - Potential sources - Waste sources by industry – Impacts – Waste control methods – Transportation regulations - Risk assessment - Remediation technologies – Private public partnership – Government initiatives.

UNIT V ULTIMATE DISPOSAL 9

Landfill – Classification – Site selection parameters – Design aspects – Leachate control – Environmental monitoring system for Land-Fill Gases.

TOTAL: 45 PERIODS

OUTCOMES

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

CO1: Summarize the characteristics of solid waste, and legal regulations
CO2: Describe the methods of solid waste collection and segregation techniques.
CO3: Illustrate the different kinds of energy generation techniques from different types of solid wastes.
CO4: Describe the practices for managing hazardous wastes.
CO5: Examine the final disposal methods for wastes.

REFERENCE BOOKS

1. Howard S. Peavyetal, Environmental Engineering, McGraw Hill International Edition, 1985
2. LaGrega, M., et al., Hazardous Waste Management, McGraw-Hill, c. 1200 pp., 2nd ed., 2001.
3. Manoj Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House,1997
4. Parker, Colin and Roberts, Energy from Waste – An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
5. Stanley E. Manahan, Hazardous Waste Chemistry, Toxicology and Treatment, Lewis Publishers, Chelsea, Michigan, 1990
6. Tchobanoglous, Theisen and Vigil, Integrated Solid Waste Management, 2d Ed.McGraw-Hill, New York, 1993.

CO-PO MAPPING

COs	**POs**			
	1	**2**	**3**	**4**
1			3	

2			2	
3			3	
4			2	
5		2	3	

COURSE CODE	COURSE TITLE	L	T	P	C
PES2328	**ELECTRONIC WASTE MANAGEMENT**	**3**	**0**	**0**	**3**

OBJECTIVE

To learn current practices of managing electronic waste, discuss key elements and terms associated with E-waste management and to addresses the issues of sustainability.

UNIT I INTRODUCTION 9

E-waste overview - Composition of e-waste - Hazardous substances present in e- waste - Indian and global scenario of e-Waste - Growth of electrical and electronics industry in India - Environmental and Health implications.

UNIT II TREATMENT METHODS 9

Electronic waste generation and management in India - Process of e-waste recycling - Thermal treatments - Incineration - Hydrometallurgical extraction - Sensing technologies - Air classification method - Pyrolysis, magnetic separation - Mechanical shredding - Cryogenic decomposition - Landfilling - Gasification process.

UNIT III RECYCLING OF E-WASTE PRODUCTS 9

Recycling printed circuit boards - Recycling liquid crystal displays - Recycling batteries - Recycling cathode ray tubes - Recycling of E-waste plastics.

UNIT IV E-WASTE LEGISLATION 9

Regulatory regime for e-waste in India - Hazardous waste (Management and Handling) rules 2003 - Waste management rules 2015 - Regulatory compliance including roles and responsibility of different stakeholders - Producer, manufacturer, consumer etc., Proposed reduction in the use of hazardous substances (RoHS) - Extended producer responsibility (EPR).

UNIT V SUSTAINABLE ELECTRONIC PRODUCT DESIGN 9

Drivers for sustainability and eco-design - Design for sustainability (DfS) - Sustainable materials and manufacturing processes - Examples of sustainable electronic product design - Future trends.

TOTAL : 45 PERIODS

OUTCOME

On successful completion of this course, the student will be able to

CO1: Describe the generation and composition aspects of E-waste.
CO2: Examine the various treatment methods of E-waste.

CO3: Develop recycling and recovery process of the materials used in the manufacture of electrical and electronic products.
CO4: Summarize the rules and regulations for E-waste management.
CO5: Articulate on sustainable electronic product design.

REFERENCE BOOKS

1. Hester, R.E, Harrison, R. M., Electronic Waste Management, RSC Pub, 2009.
2. Goodship, V., Stevels, A., Waste electrical and electronic equipment (WEEE) handbook, Woodhead Publishing, 2012.
3. Veit, H. M., Bernardes, A. M., Topics in Mining, Metallurgy and Materials Engineering, Springer International Publishing, Year: 2015
4. Kahhat, R., Hieronymi, K., Williams E, E-waste Management: From Waste to Resource, Taylor and Francis, 2007
5. Fowler, B.A., Electronic Waste: Toxicology and Public Health Issues, Elsevier, 2017
6. Johri R., "E-waste: implications, regulations, and management in India and current global best practices", TERI Press, New Delhi

CO-PO MAPPING

COs	**POs**			
	1	**2**	**3**	**4**
1			2	
2			3	2
3		3	2	2
4			3	
5			3	

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
PES2329	**PLASTIC WASTE MANAGEMENT**	**3**	**0**	**0**	**3**

OBJECTIVE

To Understand the impact of plastic waste on environment, Recycle of both commercial and engineering plastics, and the legislations related to environmental issues of plastics waste.

UNIT I PLASTIC WASTE GENERATION & SEPARATION TECHNIQUES 9

Plastics production and consumption- Plastic wastes generation source and types – Plastic waste composition, quantities - Plastics identification methods physical, chemical and instrumental – Sorting and separation technologies - Disposal alternatives – Recycling methods – Primary, secondary and tertiary recycling of plastics - Plastic road.

UNIT II PROCESSING OF COMMINGLED PLASTIC WASTE 9

Size reduction of recycled plastics – Cutting / shredding, densification, pulverization and chemical size reduction processes - Municipal solid waste and composition – Recycling of plastics from urban solid wastes - Household waste – Industrial sector – Density and mechanical properties of recyclable plastics – Processing of commingled / mixed plastic waste – Super wood, plastic lumber.

UNIT III RECYCLING OF POLYOLEFINS, PET AND PVC 9

Recycling of polyolefins – Polyethylene films – Polypropylene battery recyling- Recycling of HDPE fuel tanks - PET recycling methods – PET film recycling - Applications of polyolefin and PET recyclate – PVC recycling.

UNIT IV RECYCLING OF ENGINEERING THERMOPLASTICS 9

Engineering thermoplastics and their major areas where engineering polymers are recycled – Major recyclers of engineering plastics – GE/ Bayer/ MRC Polymers – PC, PBT, Nylon, PPO, ABS and polyacetals and their blends.

UNIT V RECYCLING OF THERMOSET COMPOSITES 9

Recycling of Polymer thermoset composites – Regrind processes - SMC scrap – Pyrolysis and energy recovery –Types of rubber products – Rubber grinding methods – Tyre grinding – Rubber crumb applications – Reclaiming and de-vulcanization processes tyre derived fuel and energy recovery – Pyrolysis of scrap tyres - Act on plastic waste management.

TOTAL: 45 PERIODS

OUTCOME

On successful completion of this course, the student will be able to

CO1: Identify various sources of plastics waste generation and separation techniques.
CO2: Describe the segregation methods for recycling the waste plastics.
CO3: Examine the recycling of Polyolefins, PET &PVC.
CO4: Discuss the recycling of engineering thermoplastics.
CO5: Analyse the primary recycling techniques of thermoset composites.

REFERENCE BOOKS

1. Subramanian Muralisrinivasan Natamai, Plastics Waste Management, 2nd edition, John Wiley & Sons Inc. 2019.
2. John Scheirs, Polymer recycling, Science, Technology and Applications, John Wiley & Sons, England, 1988.
3. Nabil Mustafa, Plastics Waste Management (Ed), Marcel Dekker, New York,1995.

4. Ann Christine Albertson and Samuel J. Huang, Degradeable polymers, Recycling and Plastic Waste Management (Eds), Marcel Dekker, New York, 1995.
5. John Schiles, Polymer Recycling: Science, Technology and Applications, Wiley, 1998.
6. Dr.J.S. Anand, Recycling & Plastics Waste Management, CIPET, 1997.

CO-PO MAPPING

COs	POs			
	1	**2**	**3**	**4**
1		2	2	
2			3	
3		2	2	2
4			3	
5			3	2

COURSE CODE	COURSE TITLE	L	T	P	C
PES2331	**AGRICULTURAL WASTE MANAGEMENT**	**3**	**0**	**0**	**3**

OBJECTIVE

To impart knowledge to students on various methods of agricultural waste management for eco-friendly energy and manure production.

UNIT I INTRODUCTION 7

Availability of different types of agriculture wastes - Its overall characteristics – Classification of agro wastes based on their characteristics- Its recycling and utilization potential- Current constraints in collection and handling of agricultural wastes – Its environmental impact.

UNIT II COMPOSTING 10

Solid waste suitable for composting – Methods of composting - Vermicomposting - mineralization process in composting - Biochemistry of composting – Factors involved – infrastructure required – Maturity parameters – Value addition – Application methods

UNIT III BIOMASS BRIQUETTING 9

Potential agro residues and their characteristics for briquetting – Fundamental aspects and technologies involved in briquetting – Economic analysis of briquetting – Setting up of briquetting plant- Appliances for biomass briquettes.

UNIT IV BIOCHAR PRODUCTION 9

Characteristics of agro wastes suitable for biochar production – Methods of biochar production – Fast and slow pyrolysis – Characteristics of biochar – Role of biochar in soil nutrition and carbon sequestration.

UNIT V BIOGAS AND BIO ETHANOL PRODUCTION 10

Screening of suitable lingo cellulosic substrate for biogas production - Determination of bio-energy potential of agro-waste by estimating total solids - Volatile solids - Calorific value- per cent total carbohydrates, moisture, lignin and cellulosic contents – Preparation of feed stocks for

anaerobic bio-digestion – Types of digesters – Factors affecting - Nutrient value and utilization of biogas slurry. Ethanol production from lingo cellulosic wastes - Processing of biomass to ethanol – Pretreatment - Fermentation - Distillation.

TOTAL:45 PERIODS

OUTCOMES

On successful completion of this course, the student will be able to

CO1: Describe the different types of agriculture wastes, its characteristics and handling.
CO2: Summarize the various methods of composting.
CO3: Examine the technologies involved in biomass briquetting and its applications.
CO4: Illustrate the methods of biochar production and its characterization.
CO5: Predict the suitable methods for biogas and bioethanol production.

REFERENCE BOOKS

1. Grover, P.D., & Mishra, S.K., Biomass Briquetting: Technology and Practices, Published by FAO Regional Wood Energy Development Programme in Asia, Bangkok, Thailand, 1996.
2. Muradin, M., & Foltynowicz, Z., Potential for Producing Biogas from Agricultural Waste in Rural Plants in Poland, Sustainability, 6, 5065-5074, 2014.
3. Kang, Q., Appels, L., Tan, T., Dewil, R., Bioethanol from Lignocellulosic Biomass: Current Findings Determine Research Priorities, The Scientific World Journal, Article ID 298153, 2014.
4. Loehr, R.C., Agricultural Waste Management- problems, processes and approaches, First edition, Academic press, 1974.
5. Ok, Y.S., Uchimiya, S.M., Chang, S.X., Bolan, N., Biochar-production characterization and applications, CRC press, 2015.

CO-PO MAPPING

COs	**POs**			
	1	**2**	**3**	**4**
1		1	3	
2		1	3	
3		1	3	
4		1	3	
5		1	3	

COURSE CODE	COURSE TITLE	L	T	P	C
PGE2946	WASTE TO ENERGY	3	0	0	3

OBJECTIVES:

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

UNITI INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNITII BIOMASS PYROLYSIS 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNITIII BIOMASS GASIFICATION 9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNITIV BIOMASS COMBUSTION 9

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNITV BIO ENERGY 9

Properties of biogas (Calorific value and composition), Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production -Urban waste to energy conversion - Biomass energy programme in India.

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the student will be able to:

CO1: Understand the various types of wastes from which energy can be generated
CO2: Gain knowledge on biomass pyrolysis process and its applications
CO3: Develop knowledge on various types of biomass gasifiers and their operations

CO4: Gain knowledge on biomass combustors and its applications on generating energy
CO5: Understand the principles of bio-energy systems and their features

REFERENCES:

1. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

Mapping of courses – B. Tech I.T

	Sustainable Development Goals																
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Artificial Intelligence								✓	✓		✓						
Cyber Security											✓					✓	
Sensors and Actuators								✓	✓		✓						
Image Processing and Computer Vision								✓	✓		✓						
Healthcare Analytics								✓	✓		✓						
Cyber Forensics and Information Security									✓		✓					✓	
IOT Architectures and Applications								✓	✓		✓						
Forensic Analytics									✓		✓					✓	
Human Computer Interaction								✓	✓		✓						
FinTech Security									✓		✓					✓	
Mobile Autonomous Robots								✓	✓		✓						

Mapping of courses with SDGs – M.E. Power Electronic Devices

Course	**Sustainable Development Goals**																
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Electric and Hybrid Vehicles							✓	✓	✓		✓		✓				✓
Energy Storage Technologies							✓	✓	✓								
Design of Solar Photovoltaic Systems							✓	✓	✓								

EV Batteries and Charging systems								✓	✓		✓						
Energy Management and Auditing							✓		✓			✓					
Testing of EV and HEV								✓	✓		✓						
Power Electronics for Solar and Wind Energy Conversion Systems							✓	✓	✓								

Course Code	Course Title	L	T	P	C
PPE2202	**ELECTRIC AND HYBRID VEHICLES**	3	0	0	3

Objectives:

- To understand the concept of electrical vehicles and its operations.
- To understand the need for energy storage in hybrid vehicles.
- To provide knowledge about various possible energy storage technologies that can be used in electric vehicles.

Unit I	**EV Architecture and Vehicle Mechanics**	**9**

Electric Vehicles: Types of EV, EV Architecture, Vehicle mechanics, Performance of Electric Vehicles, Vehicle power plant and transmission characteristics, Operating Fuel Economy and Braking Performance – TN Electric vehicle Policy.

Unit II	**Internal Combustions Engines and HEV**	**9**

IC Engines: Types of IC Engines, Practical and Air-Standard Cycles.Basic concept of hybrid traction, introduction to various hybrid drive and drive trains. Sizing the hybrid electric drive system: matching the electric machine and the internal combustion engine (ICE), sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, communications, supporting subsystems.

Unit III	**Motors and Control Systems**	**9**

DC Drives: Two quadrant DC drives operation, Four quadrant DC drives operation, Open Loop Control.

AC Drives: Vector Control and Flux Control methods of Induction Motor and Synchronous Motor – Voltage Controlled and Current Controlled methods of Switched reluctance motor drives.

Unit IV	**Battery and Other Alternate Energy Storage System**	**9**

Battery Basics, Different types, Battery Parameters, Battery modelling, Traction Batteries.
Fuel cell – Characteristics- Types – hydrogen Storage Systems and Fuel cell EV – Ultra capacitors.

Unit V	**Powertrain Technologies and Management Systems**	**9**

Introduction to Powertrain Technologies, Power Flow Control in Hybrid Drive Train Topologies, Fuel Efficiency Analysis. Energy Management Strategies: Introduction and classification-Performance characteristics – Driving Cycles, comparison of different energy management strategies, implementation issues of energy management strategies.

Total Periods	**45**

Course Outcomes: Upon successful completion of the course, students will be able to
CO1: Summarise the basics of electric vehicle and vehicle mechanics.
CO2: Explain the basics of internal combustion engines and design of HEV.
CO3: Discuss the concepts of HEV motor and its controls.
CO4: Demonstrate the use of battery and alternate energy storage systems.
CO5: Explain the power train technology and management systems of the EV.
Text Books:
1. Khajepour, Amir, Mohammad SaberFallah and Avesta Goodarzi. 'Electric and Hybrid Vehicles: Technologies, Modeling and Control - A Mechatronic Approach' Wiley,2014.
2. James Larminie, John Lowry, 'Electric Vehicle Technology Explained', John Wiley & Sons, Ltd., 2003.
3. Ehsani, Mehrdad, Yimin Gao and Ali Emadi. 'Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design', CRC Press, New York, USA, 2009.
References:
1. K. T. Chau, 'Electric Vehicle Machines and Drives: Design, Analysis and Application', Wiley, 2015.
2. C.C. Chan and K.T. Chau, 'Modern Electric Vehicle Technology', London: Oxford University Press, 2001.
3. Iqbal Hussain, 'Electric and Hybrid Vehicles: Design Fundamentals', Second Edition" CRC Press, Taylor & Francis Group, Second Edition, 2011.
4. Ali Emadi, Mehrdad Ehsani, John M.Miller, 'Vehicular Electric Power Systems', Special Indian Edition, Marcel Dekker, Inc 2010.

COs	**POs**			
	1	**2**	**3**	**4**
1			2	
2		2	2	2
3	2	2	3	2
4	2	2	2	2
5	2	2	2	1

Course Code	**Course Title**	**L**	**T**	**P**	**C**
PPE2222	**ENERGY STORAGE TECHNOLOGIES**	3	0	0	3

Objectives:

- To develop the ability to understand / analyse the various types of energy storage.
- To study the various applications of energy storage systems.

Unit I	**Introduction**	**9**

Necessity of Energy Storage – Relevance and scenario. Perspective on development of Energy storage systems. Energy storage criteria, General concepts. Conventional batteries – fundamentals and applications. Grid connected and Off grid energy storage systems and requirements. – Comparison of Energy Storage Technologies – Applications.		
Unit II	**Thermal Storage System**	**9**
Thermal Storage –Thermal properties of materials, Principle of operations, Efficiency factors, large scale and medium scale operations – Types: Simple Water and Rock Bed Storage System – Pressurized Water Storage System –Phase Change Storage System – Packed Bed Storage Units.		
Unit III	**Electrical Energy Storage**	**9**
Fundamental Concept of Batteries – Measuring of Battery Performance, Charging, And Discharging of a Battery, Storage Density, Energy Density, And Safety Issues. Types of Batteries – Lead Acid, Nickel – Cadmium, Zinc Manganese Dioxide and Modern Batteries for Example (i) Zinc-Air (ii) Nickel Hydride, (iii) Lithium Battery.		
Unit IV	**Fuel Cell**	**9**
Introduction to fuel cell – Types- Operation, Modelling and characteristics, Proton exchange membrane (PEM) fuel cell, Solid oxide fuel cell – Applications. Hydrogen storage system – solid state hydrogen storage tanks, gas phase hydrogen storage tanks, cryogenic and liquid phase hydrogen storage tanks.		
Unit V	**Alternate Energy Storage Technologies**	**9**
Flywheel, Super capacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications.		
	Total Periods	**45**
Course Outcomes: Upon successful completion of the course, students will be able to		
CO1: Understand the basics of energy storage system.		
CO2: Explain the thermal storage system and its importance.		
CO3: Discuss the fundamentals of the electrical storage systems and their applications.		
CO4: Describe about the fuel cell technology, advantages and its drawbacks.		
CO5: Summarise the alternate energy storage technology and its applications.		
Textbooks:		
3. Zobaa, Ahmed F., ed., 'Energy Storage: Technologies and Applications', BoD –Books on Demand, 2013.		
4. Sterner, Michael, and Ingo Stadler, eds. 'Handbook of energy storage: Demand, technologies, integration', Springer, 2019.		

References:
1. Ibrahim Dincer and Mark A. Rosen, 'Thermal Energy Storage Systems and Applications', John Wiley & Sons, 2002.
2. James Larminie and Andrew Dicks, 'Fuel cell systems Explained', Wiley publications, 2003.

3. Lunardini.V.J, 'Heat Transfer in Cold Climates', John Wiley and Sons 1981.
4. Ru-shiliu, Leizhang and Xueliang sun, 'Electrochemical technologies for energy storage and conversion', Wiley publications, 2012.
5. Schmidt.F.W and Willmott.A.J, 'Thermal Storage and Regeneration', Hemisphere Publishing Corporation, 1981.

COs	POs			
	1	**2**	**3**	**4**
1			1	
2	2	1	1	2
3	2	2	1	1
4	2	2	1	1
5	2	2	1	1

Course Code	Course Title	L	T	P	C
PPE2223	**DESIGN OF SOLAR PHOTOVOLTAIC SYSTEMS**	3	0	0	3

Objectives:

- To study solar energy conversion methods and the operation of PV systems.
- To explore the design issues in standalone and grid connected PV systems.
- To discuss about safety and standards of PV system installation.
- To familiarize the design of PV systems for various applications.

Unit I	**Introduction**	**9**
Introduction to solar energy, solar energy conversion methods – Characteristics of sunlight – Semiconductors and P-N junctions – Behaviour of solar cells – Cell properties – PV cell interconnections.		
Unit II	**Standalone PV Systems**	**9**
Solar modules – Storage systems – Power conditioning and Regulation - Protection – Design and Sizing of standalone PV systems.		
Unit III	**Grid Connected PV Systems**	**9**
PV systems in buildings – Design issues for central power stations – Economic aspect – Efficiency and Performance – International PV programs – Life cycle costing.		
Unit IV	**Installation, safety and Standards**	**9**
Installation and troubleshooting of solar PV systems/power plants – Safety in installation – Installation check list – Case studies of PV system installation – Codes and Standards for PV modules and systems		
Unit V	**Applications**	**9**
Water pumping – Battery chargers – Solar car – Direct-drive applications – Space – Telecommunications.		
	Total Periods:	**45**

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

CO1: Explain the photovoltaic principles and techniques of solar energy conversion.

CO2: Illustrate the design of standalone PV system.

CO3: Describe the design of grid connected PV system.

CO4: Describe the safety aspects and standards involved in the installation of solar PV systems.

CO5: Design PV system for real world applications.

Text Books:

1. Stuart R Wenham, Martin A Green, Muriel E Watt and Richard Corkish, 'Applied Photovoltaics', Earthscan, UK, 2007.
2. Chetan Singh Solanki, 'Solar Photovoltaic Technology and Systems – A Manual for Technicians, Trainers and Engineers', PHI Learning Private Limited, Delhi, India, 2013.

References:

1. Chetan Singh Solanki, 'Solar Photovoltaics: Fundamentals, Technologies and Applications', PHI Learning Pvt. Ltd., 2018.
2. Andy Walker, 'Solar Energy: Technologies and Project Delivery for Buildings', Wiley India Pvt. Ltd., 2014.
3. Eduardo Lorenzo G. Araujo, 'Solar Electricity Engineering of Photovoltaic Systems', Progensa, 1994.
4. Tiwari G N and Swapnil Dubey, 'Fundamentals of Photovoltaic Modules and Their Applications', RSC Energy series 2, UK, 2010.

COs	**POs**			
	1	**2**	**3**	**4**
1		1	1	
2	3	2	2	2
3	3	2	2	3
4	3	1		
5	3	3	3	2

Course Code	**Course Title**	**L**	**T**	**P**	**C**
PPE2227	**EV BATTERIES AND CHARGING SYSTEMS**	3	0	0	3

Objectives:

- To understand the types and characteristics of batteries for EV
- To understand the concept of battery modelling and battery management system
- To provide knowledge about various types of charging infrastructure and chargers

Unit I	**Battery Characteristics and Parameters**	**9**
Cells and Batteries – conversion of chemical energy to electrical energy – Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics; Efficiency of batteries; Electrical parameters Heat generation.		
Unit II	**Chemistry of EV Batteries**	**9**
Special characteristics, Battery life and maintenance of Lead Acid Batteries – Nickel-based Batteries Nickel cadmium, Nickel metal hydride batteries – Sodium-based Batteries Sodium sulphur batteries, Sodium metal chloride (Zebra) batteries – Lithium Batteries lithium polymer battery, lithium-ion battery – Metal Air Batteries – Aluminium air battery, Zinc air battery.		
Unit III	**Battery Modelling and Battery Management System**	**9**
General approach to modelling batteries, simulation model of a rechargeable Li-ion battery, simulation model of a rechargeable NiCd battery, Parameterization of the NiCd battery model, State-of-the-Art of battery State-of-Charge determination – State-of-Charge indication algorithms and methods – Cell equalization problem, Energy & Power estimation, Battery thermal management system		
Unit IV	**Charging Infrastructure**	**9**
Domestic Charging Infrastructure, Public Charging Infrastructure, Normal Charging Station, Occasional Charging Station, Fast Charging Station, Battery Swapping Station, Move-and-charge zone.		
Unit V	**Battery Chargers and Connectors**	**9**
Battery Chargers: Charge equalisation, Conductive charging – Basic charger, Microprocessor based charger – Arrangement of an off-board conductive charger, Standard power levels of conductive chargers, Inductive Principle of inductive charging- Soft-switching power converter for inductive charging. **Connectors:** Different types of EV charging connectors in India – AC and DC Connectors: IEC60309,Type 1 and 2, GB/T, CHAdeMO, CCS1, CCS2, DC Fast Charge EV Plug – Standards		
	Total Periods:	**45**
Course Outcomes: Upon successful completion of the course, students will be able to		
CO1: Describe about the battery characteristics & parameters.		
CO2: Discuss about the different types of EV batteries.		
CO3: Analyse different types of modelling and battery management system.		
CO4: Explain the different types of charging infrastructure.		
CO5: Describe different types of battery chargers and connectors.		

Textbooks:
1. Iqbal Hussain, 'Electric and Hybrid Vehicles: Design Fundamentals', CRC Press, Taylor & Francis Group, Second Edition, 2011.

2. Ali Emadi, Mehrdad Ehsani, John M.Miller, 'Vehicular Electric Power Systems', Special Indian Edition, Marcel Dekker, Inc., 2010.
3. James Larminie, John Lowry, 'Electric Vehicle Technology Explained', John Wiley & Sons Ltd, 2003.
4. C.C Chan, K.T Chau, 'Modern Electric Vehicle Technology', Oxford University Press Inc., New York, 2001.
5. Gregory L. Plett, 'Battery Management Systems: Battery modelling', Artech House, 2015.

References:

1. K. T. Chau, 'Electric Vehicle Machines and Drives: Design, Analysis and Application', Wiley, 2015.
2. C.C. Chan and K.T. Chau, 'Modern Electric Vehicle Technology', London: Oxford University Press, 2001.
3. Sheldon S. Williamson, 'Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles', Springer, 2013.
4. T R Crompton, 'Battery Reference Book-3 rd Edition', Newnes-Reed Educational and Professional Publishing Ltd., 2000.
5. Alam, Mohammad Saad, Pillai, Reji Kumar, Murugesan, 'Developing Charging Infrastructure and Technologies for Electric Vehicles', IGI Global, 2021.

COs	**POs**			
	1	**2**	**3**	**4**
1			3	
2			3	
3	1	2	3	2
4	1	2	3	2
5	1	2	3	2

Course Code	**Course Title**	**L**	**T**	**P**	**C**
PPE2234	**ENERGY MANAGEMENT AND AUDITING**	3	0	0	3

Objectives:

- To study the concepts behind economic analysis and Load management.
- To emphasize the energy management on various electrical equipment and metering.
- To illustrate the concept of lighting systems and cogeneration.

Unit I	**Introduction**	**9**

Need for energy management - energy basics- designing and starting an energy management program – energy accounting -energy monitoring, targeting and reporting- energy audit process.

Unit II	**Energy Cost and Load Management**	**9**

Important concepts in an economic analysis - Economic models-Time value of money-Utility rate structures- cost of electricity-Loss evaluation- Load management: Demand control techniques-Utility monitoring and control system-HVAC and energy management-Economic justification.		
Unit III	**Energy Management for Motors, Systems and Electrical Equipment**	**9**
Systems and equipment- Electric motors -Transformers and reactors-Capacitors and synchronous machines.		
Unit IV	**Metering for Energy Management**	**9**
Relationships between parameters-Units of measure-Typical cost factors- Utility meters - Timing of meter disc for kilowatt measurement - Demand meters - Paralleling of current transformers - Instrument transformer burdens-Multitasking solid-state meters - Metering location vs. requirements- Metering techniques and practical examples.		
Unit V	**Lighting Systems and Cogeneration**	**9**
Concept of lighting systems - The task and the working space -Light sources - Ballasts - Luminaries - Lighting controls-Power factor and effect of harmonics on power quality - Cost analysis techniques-Lighting and energy standards Cogeneration: Forms of cogeneration - feasibility of cogeneration- Electrical interconnection.		
	Total Periods:	**45**
Course Outcomes: Upon successful completion of the course, students will be able to		
CO1: Develop the ability to learn about the need for energy management and auditing process		
CO2: Understand the basic concepts of economic analysis and load management		
CO3: Understand the energy management on various electrical equipment		
CO4: Acquire knowledge on the concepts of metering and factors influencing cost function		
CO5: Familiarize the concept of lighting systems, light sources and various forms of cogeneration		
Text Books:		
1. Barney L Capehart, Wayne C Turner and William J Kennedy, "Guide to Energy Management", 5th Edition, The Fairmont Press, Inc., 2006.		
2. Eastop T D and Croft D R, "Energy Efficiency for Engineers and Technologists", Logman Scientific Technical, 1990.		

References:
1. Reay D A, "Industrial Energy Conservation", 1st edition, Pergamon Press, 1977.
2. IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE 196.
3. Amit K Tyagi, "Handbook on Energy Audits and Management", TERI, 2003.
4. Electricity in buildings good practice guide, APQI, ICAI, McGraw-Hill Education, 2016.

COs	POs			
	1	**2**	**3**	**4**
1	1	1	2	
2	3	1	1	
3	3	2	1	2
4	3	3	2	2
5	3		2	

Course Code	**Course Title**	**L**	**T**	**P**	**C**
PPE2322	**TESTING OF EV AND HEV**	3	0	0	3

Objectives:

This main course objectives are as follows:

- To classify vehicles into different categories and to know about salient feature of electrification of drive
- To introduce various driver assistance systems along with testing of vehicle components based on standards test by Automotive Research Association of India (ARAI)
- To expose students to various test prescribed by ARAI for Hybrid E vehicles

Unit I	**Introduction**	**9**

Specification and Classification of Vehicles (including M, N and O layout), Homologation & its Types, Regulations overview (EEC, ECE, FMVSS, AIS, CMVR), Type approval Scheme, Homologation for export, Conformity of Production, various Parameters, Instruments and Types of test tracks, Hardware in The Loop (HIL) concepts for EV/HEVs

Unit II	**Electrification of Drive**	**9**

Electrification of the drive – Features – Components of the electrified drive – Regenerative braking system – Thermal management for electric vehicles - Charging infrastructure – Control of electric drives – Hybrid Drive – Electric Drives with fuel cell.

Unit III	**Driver Assistance Systems**	**9**

Ultrasonic, Radar, Lidar and Video sensors – Vehicle navigation – night vision – Parking and manoeuvring – Adaptive cruise control – Lane assistance – Information and warning – Intelligent head lamp control – Emergency braking systems

Unit IV	**Vehicle Component Testing**	**9**

Horn Testing, Safety Glasses Test: Windscreen laminated and toughened safety glass, Rear View Mirror Test, Hydraulic Brakes Hoses Fuel Tank Test: Metallic & Plastic, Hinges and Latches Test, Tyre & Wheel Rim Test, Bumper Impact Test, Side Door Intrusion, Crash test with dummies, Demist test, Defrost Test, Interior Fittings, Steering Impact test (GVW<1500 kg), Body block test, Head form test, Driver Field Of Vision, Safety belt assemblies, Safety belt anchorages, Seat anchorages and head restraints test, Airbag Test, Accelerator Control System, Motor power, Safety Requirements of Traction Batteries

Unit V	**Tests for Hybrid Electric Vehicles**	**9**

Hybrid Electric Vehicles Tests (M and N category), Tests for Hybrid Electric System Intended for Retro-fitment on Vehicles of M and N Category (GVW < 3500 kg), Test for

Electric Propulsion kit intended for Conversion, Test for Electric Vehicle Conductive AC Charging System, and Test for Electric vehicle conductive DC charging system	
Total Periods	**45**
Course Outcomes: Upon successful completion of the course, students will be able to	
CO1: Explain classification, homologation, regulations governing Electric and Hybrid vehicles	
CO2: Summarize the electrification of drives for Electric and hybrid vehicle application.	
CO3: Illustrate the various driver assistance systems available in automobile vehicles.	
CO4: Explain various vehicle component testing based on standards approved by ARAI	
CO5: Describe various tests approved by ARAI for hybrid electric vehicles	
Text Books:	
1. Michael Plint and Anthony Martyr, "Engine Testing & Practice", Butterworth Heinmenn, 3rd ed, 2007	
2. Robert Bosch, "Bosch Automotive Handbook", 7th Edition, 2007.	
References:	
1. Proceedings- Automotive Testing & Certification held on 20th to 24th July 2010 at ARAI PUNE accessible at https://www.araiindia.com/downloads - accessed on May 14, 2022	
2. American Association of Motor Vehicle Administrators, "Vehicle Inspection Handbook".	

COs	**POs**			
	1	**2**	**3**	**4**
1		1	2	
2	1		3	3
3	1		3	
4	1	2	2	
5	1	2	3	2

Course Code	**Course Title**	**L**	**T**	**P**	**C**
PPE2323	**POWER ELECTRONICS FOR SOLAR AND WIND ENERGY CONVERSION SYSTEMS**	3	0	0	3

Objectives:

- To provide knowledge about different types of renewable energy sources.
- To understand the operation of various generators used for wind energy conversion system.
- To analyse the power converters for solar PV and wind energy conversion system.
- To understand the importance of standalone, grid-connected, and hybrid operation in renewable energy systems.

Unit I	**Introduction**	**9**

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) -Qualitative study of different renewable energy resources ocean, Biomass, Hydrogen energy systems-Operating principles and characteristics of Solar PV, Fuel cells and wind energy systems- Present Indian and International energy scenario of conventional and renewable energy sources.		
Unit II	**Wind Energy Conversion System**	**9**
Overview of Wind turbine technology-Principle of reference theory fundamentals-types of generators -principle of operation and analysis: SCIG, DFIG and PMSG.		
Unit III	**Power Electronics for Wind Energy System**	**9**
Overview of power converters for wind energy conversion system (WECS)- Voltage source inverter for WECS, matrix converter- Control aspects of wind energy conversion system: SCIG, DFIG and PMSG based WECS - Grid connection issues.		
Unit IV	**Power Electronics for Solar PV System**	**9**
Block diagram of solar PV system – DC-DC converters -DC-AC Converter-Multilevel inverter-based PV system- Overview of MPPT techniques-Sizing of standalone PV system - Grid tied and grid interactive inverters- grid codes- grid connection issues.		
Unit V	**Hybrid Systems**	**9**
Need for Hybrid Systems -Configurations-types - case studies of Diesel-PV, Wind-PV, Micro hydel-PV, Biomass-Diesel hybrid systems.		
	Total Periods	**45**
Course Outcomes: Upon successful completion of the course, students will be able to		
CO1: Examine the various renewable energy sources and its impact on the environment.		
CO2: Explain the operating principle of electrical machines used in wind energy conversion system.		
CO3: Analyse the power electronic converters utilized for wind energy systems		
CO4: Analyse the power electronic converters utilized for solar PV systems		
CO5: Discuss the hybrid renewable energy systems.		
Textbooks:		
1. S. N. Bhadra, D. Kastha, S. Banerjee, “Wind Electrical Systems”, Oxford University Press, 2005		
2. R. Seyezhai and R. Ramaprabha, “Power Electronics for Renewable Energy Systems”, SciTech Publications, 2015.		
References:		
1. B.H. Khan, “Non-conventional Energy sources”, Tata McGraw-Hill Publishing Company, New Delhi, 2017.		
2. Tiwari G N and Swapnil Dubey, “Fundamentals of Photovoltaic Modules and Their Applications”, RSC Energy series 2, UK, 2010.		
3. Rashid. M. H “Power electronics Handbook”, Academic press,2nd Edition, 2006.		
4. Ion Boldea, “Variable speed generators”, Taylor & Francis group, 2006.		
5. Rai. G.D,” Solar energy utilization”, Khanna publishes, 1993.		

COs	**POs**			
	1	**2**	**3**	**4**

1			2	2
2	1		3	3
3	1	2	3	3
4	1	2	3	3
5		1	2	2

Mapping of courses with SDGs– M.E. Manufacturing

Course	**Sustainable Development Goals**																
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Robotics & Automation								✓	✓								✓
Artificial Intelligence in Manufacturing								✓	✓								
Lean and Cellular Manufacturing								✓	✓								
Design for Manufacture, Assembly and Environment								✓	✓								
Sustainable & Green Manufacturing Practices								✓	✓				✓		✓		✓

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
PMF2102	**ROBOTICS & AUTOMATION**	**3**	**0**	**0**	**3**

OBJECTIVE:

- To impart knowledge in the areas of design, simulation, control of robots and automation.

UNIT I INTRODUCTION TO ROBOTICS **7**

Definition, specification and need based applications; Types of robots – Classifications – Configuration, work volume, control loops, controls and intelligence, future of robotics and automation-ethical issues - Degrees of freedoms, case study on industrial serial arm manipulator

UNIT II ROBOT SENSORS AND ACTUATORS **9**

Characteristics of actuating systems, Types of electric motors - DC, Servo, Stepper; specification, drives for motors - speed & direction control and circuitry, Selection criterion for actuators, non-traditional actuators - Sensors for localization, navigation, obstacle avoidance and path planning

in known environments - Case study on choice of sensors and actuators for mobile robots

UNIT III DESIGN OF ROBOTS & END-EFFECTORS 9

Robot kinematics - Geometric approach for 2R, 3R manipulators, homogenous transformation using D-H representation, Mechanical design aspects of a 2R manipulator, WMR - End-effector - common types and design case study

UNIT IV ROBOT SIMULATION & MOTION CONTROL 10

Kinematics of WMR, Trajectory planning, Mapping & Navigation – SLAM in Webots/Gazebo simulator; ROS- Introduction, framework, emulation of manipulator examples

UNIT V AUTOMATION & MACHINE LEARNING 10

Types of Programming – Arduino Micro-controller for simple automations – AI, Expert systems Application of Machine learning – case study on Assistive robot

TOTAL PERIODS: 45

OUTCOMES: At the end of this course, the students will be able to:

CO#	Course Outcome	Level
CO1	Explain the concepts of industrial robots on classification, specification, future prospects and application relating to the need of robot & automation	U : K2
CO2	Examine different sensors and actuators for standard industrial applications	Ap : K3
CO3	Design a 2R robot & an end-effector and solve the kinematics and dynamics of motion for robots	An : K4
CO4	Explain robot motion planning using simulation tools and ROS	Ap : K3
CO5	Explain AI implications and the design of simple automations using microcontroller	Ap : K3

CO/PO & PSO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	1		3	2	3	1
CO2	1		3		3	2
CO3	2		3		3	2
CO4	2	1	3		3	2
CO5	2	2	3	2	3	1

REFERENCES:

1. Saeed.B.Niku, Introduction to Robotics, Analysis, system, Applications, Pearson Educations, 2002.
2. Groover M.P, Industrial Robotics, McGraw – Hill International edition, 1996.
3. N. P. Padhy, Artificial Intelligence and Intelligent Systems, Oxford University Press, 2005

4. Morgan Quigley, Brian Gerkey, Bill Smart, Programming Robots with ROS: A Practical Introduction to the Robot Operating System, O'Reilly Media; 1st edition, 2015.
5. Gordon Mair, Industrial Robotics, Prentice Hall (U.K.) 1988.
6. Richard David Klafter, Thomas A. Chmielewski, Michael Negin, Robotic engineering: an integrated approach, Prentice Hall, 1989.
7. Robin Murphy, Introduction to AI Robotics, MIT Press, 2000.
8. Wesley E Snyder R, Industrial Robots, Computer Interfacing and Control, Prentice Hall International Edition, 1988.

COURSE CODE	COURSE TITLE	L	T	P	C
PMF2228	ARTIFICIAL INTELLIGENCE IN MANUFACTURING	3	0	0	3

OBJECTIVE:

- To expose graduates to an Industrial Culture so that recruiting companies can quick launch the graduates into their work orbits just by providing the required technical skills.

UNIT I INTRODUCTION TO SOFT AND HARD COMPUTING 9

Introduction to soft computing, hard computing, Need for soft computing- Optimization and Evolutionary Computation - Conventional Optimization Tools - Non Conventional Optimization Tools – Basics of Machine Learning - Supervised and Unsupervised learning - Application of Soft Computing Techniques in Manufacturing

UNIT II FUZZY LOGIC 9

Fundamentals of Fuzzy Logic: Membership functions, Fuzzy Operators and Relations – Fuzzy propositions and implications – Defuzzification - Fuzzy Logic Controller Demonstration: Simulation of Mechanical System in Fuzzy using MATLAB / Python

UNIT III NEURAL NETWORK 9

Basics of Neural Network – Neural Network Architectures – The Perceptron – Gradient Descent Algorithm - Forward Propagation – Backpropagation – Loss Functions – Activation Functions – Normalization- Optimization Linear Filters - Least Mean Square Algorithm.
Demonstration: Simulation of Neural Network model using MATLAB / Python

UNIT IV OPTIMIZATION ALGORITHMS 9

Binary Coded Genetic Algorithm – Real Coded Genetic Algorithm – Particle Swarm Optimization – Simulated Annealing – Multi objective Optimization

Demonstration: Simulation of PSO & GA using MATLAB / Python

UNIT V APPLICATION OF ARTIFICIAL INTELLIGENCE 9

Case Study: Optimization of Manufacturing Process - Defect Classification – Prognostics – Manufacturing cells and machine controls – Additive Manufacturing – Non Destructive Testing

TOTAL PERIODS: 45

OUTCOMES: At the end of this course, the students will be able to:

CO#	Course Outcome	Level
CO1	To Identify and describe soft computing techniques and their roles in Industry	R : K1
CO2	Apply fuzzy logic and reasoning to handle uncertainty and solve various engineering problem	Ap : K3
CO3	Apply ANN principles to develop expert systems to solve a manufacturing problem in Industry	Ap : K3
CO4	To understand various optimization algorithms concepts and applications	U : K2
CO5	To enable the student to select an appropriate Artificial intelligence technique and solve an optimization problem in Manufacturing Industry	Ap : K3

CO/PO & PSO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	1		3		3	1
CO2	2		3		3	1
CO3	2		3		3	1
CO4	2	1	3		3	1
CO5	2	1	3		3	1

REFERENCES:

1. R. Rajasekaran and G. A and Vijayalakshmi Pa, Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications, Prentice Hall of India [978-8126577132]
2. S. N. Sivanandam and S. N.Deepa, Principles of soft computing – John Wiley & Sons, 2007 [ISBN 978-8126527410]
3. Timothy J. Ross, Fuzzy Logic with engineering applications, John Wiley & Sons, 2016
4. Simon Haykin, “Neural Networks and Learning Machines Hardcover – Illustrated, Third Edition, [ISBN-13 : 978-0131471399]
5. Carlos A. Coello Coello, Gary B. Lamont, David A. Van Veldhuizen, “Evolutionary Algorithm for Solving Multi-objective, Optimization Problems (2nd Edition)”2007.[ISBN: 978-0-387-36797-2]

COURSE CODE	COURSE TITLE	L	T	P	C
PMF2231	LEAN AND CELLULAR MANUFACTURING	3	0	0	3

OBJECTIVE:

- To implement lean and cellular manufacturing concepts in the industry

UNIT I LEAN SYSTEM AND LEAN MANUFACTURING TOOLS 9

Origin of lean production system – Lean revolution in Toyota – Basic image of lean production – Customer focus and Customer satisfaction – Muda (waste) - 5S – Lean manufacturing tools – Changeover/setup time (SMED) – Production levelling -Line balancing -Spaghetti diagram – Design of Experiments – Taguchi Optimization – Response Surface Methodology.

UNIT II LEAN SIX SIGMA 9

Six sigma - Definition – DMAIC and DMADV deployment models – Pareto analysis - critical to quality metrics – Kaizen - SIPOC - analyzing the source of variation - cause and effect diagram – FMEA – TPM – Objectives and functions

UNIT III JIT AND OUTSOURCING 9

Principles of JIT – JIT system – Kanban – Kanban rules – Expanded role of conveyance – Pull systems – Value stream mapping **–** QFD - Vendor rating and Value Analysis - Outsourcing - Make vs. buy approach.

UNIT IV JIDOKA AND WORKER INVOLVEMENT 9

Jidoka concept – Poka-Yoke (mistake proofing) systems – Inspection systems and zone control – Types and use of Poka-Yoke systems – Implementation of Jidoka - Involvement – Activities to support involvement – Quality circle activity – Quality Planning

UNIT V CELLULAR MANUFACTURING 9

Group Technology – Limitations of traditional manufacturing systems – Group machining concept – Principle of cellular manufacturing – Terminology associated with cellular manufacturing – Characteristics and perspectives of cellular manufacturing – Areas of applications of cellular manufacturing – Benefits and limitations of cellular manufacturing

TOTAL: 45 PERIODS

OUTCOMES: At the end of this course, the students will be able to:

CO#	Course Outcome	Level
CO1	Apply the Lean manufacturing tools for a given scenario	Ap : K3
CO2	Discuss the concepts of lean six sigma	U : K2
CO3	Discuss the importance of JIT and Kanban	U : K2
CO4	Explain the principles of Jidoka and Poka Yoke	U : K2
CO5	Discuss the principle and application of group technology	Ap : K3

CO/PO & PSO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	1		3		3	1
CO2	1		3		3	1
CO3	1		3		3	1
CO4	1	1	3		3	1
CO5	1	1	3		3	1

REFERENCES:

1. Michael, L.G., "Lean Six SIGMA: Combining Six SIGMA Quality with Lean Production Speed",McGraw Hill, 2002.
2. Ohno, T.," Toyota Production System: Beyond Large-Scale Production", Taylor & Francis, Inc.,1988.
3. Nagendra Parashar, B. S., "Cellular Manufacturing Systems: An Integrated Approach" PHI Learning, 2010.
4. Dennis P.," Lean Production Simplified: A Plain-Language Guide to the World's Most Powerful Production System", (Second edition), Productivity Press, New York, 2007.
5. Liker, J., "The Toyota Way : Fourteen Management Principles from the World's Greatest Manufacturer",McGraw Hill, 2004.
6. Rother, M., and Shook, J.,' Learning to See: Value Stream Mapping to Add Value and Eliminate MUDA", Lean Enterprise Institute, 1999.
7. Askin, R. G., &Vakharia, A.J., "GT planning and operation", as in Cleland, D. I., &Bidanda, B.,(Editors), "The Automated Factory – Hand Book: Technology and Management", TAB Professional & Reference Books, NY, 1990.
8. Shahrukh A. Irani, "Handbook of Cellular Manufacturing Systems", John Wiley & Sons, 1999.

COURSE CODE	COURSE TITLE	L	T	P	C
PMF2235	DESIGN FOR MANUFACTURE, ASSEMBLY AND ENVIRONMENT	3	0	0	3

OBJECTIVE

- To introduce the principles of design for manufacturing of the products and impart knowledge on various design aspects to be considered for manufacturing using different processes.

UNIT I TOLERANCE ANALYSIS **9**

General steps in Design and manufacturing processes, Importance of tolerance and FITs in manufacturing and assembly, Matching design tolerances with appropriate manufacturing process – manufacturing process capability metrics, Tolerance stacking analysis- Worst case, statistical tolerance Analysis.

UNIT II CONCEPT OF GD&T **9**

Fundamentals of geometric dimensioning and tolerancing – Rules and concepts of GD&T – Datum systems-Form controls-Orientation controls-Tolerance of position-Concentricity and symmetry controls – Run out controls – Profile controls.

UNIT III DFM GUIDELINES FOR CASTING AND FORMING **9**

Casting – classification of casting by Mold Material, Method of Filling the Mold, Metal to be Cast, Casting Defects, DFM guidelines for casting.

Forming- Definition of forming, Plastic Deformation, Rolling, Metal Drawing, Extrusion, Forging, Cold Forming Processes, DFM guidelines for Formed metal components

UNIT IV DESIGN FOR ASSEMBLY **9**

Introduction to assembly design, Types and Characteristics of Assembly Methods, Selection of Assembly Method– Manual Assembly, Automatic Assembly, Robotic Assembly, Boothroyd and Dewhurst method of DFMA

UNIT V DESIGN FOR THE ENVIRONMENT **9**

Introduction – Environmental objectives – Global issues – Regional and local issues – Basic DFE methods-Lifecycle assessment method – Techniques to reduce environmental impact – Design to minimize material usage – Design for recyclability – Design for energy efficiency – Design to regulations and standards.

TOTAL: 45 PERIODS

OUTCOMES: At the end of this course, the students will be able to:

CO#	Course Outcome	Level
CO1	Explain the importance of tolerances in manufacturing and assembly of components	U : K2
CO2	Explain the concept of GD&T	U : K2
CO3	Summarize DFM guideline to be followed during casting and forming processes	U : K2
CO4	Explain the principles of design for assembly	U : K2
CO5	Explain the principles of design for environment.	U : K2

CO/PO & PSO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	1		3		3	1
CO2	1		3		3	1
CO3	1		3		3	1
CO4	1	1	3		3	1
CO5	1	1	3	2	3	1

REFERENCES:

1. Alex Krulikowski, "Fundamentals GD&T", Delmar Thomson Learning, 1997.
2. C.M. Creveling, "Tolerance Design – A handbook for Developing Optimal Specifications", Addison – Wesley, 1997.
3. Geoffrey Boothroyd, Peter Dewhurst, Winston.A.Knight, Product design for manufacture and assembly, Third Edition .CRC press, 2012.
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COURSE CODE	COURSE TITLE	L	T	P	C
PMF2232	SUSTAINABLE & GREEN MANUFACTURING PRACTICES	3	0	0	3

OBJECTIVE:

- To introduce the fundamental concepts of sustainable and green manufacturing practices to the students.

UNIT I SUSTAINABILITY AND DEVELOPMENT CHALLANGES 9

Definition of sustainability. Environmental, economic, and social dimensions of sustainability. Sustainable development models – strong and weak sustainability. Defining development - Millennium development goals. Mindsets for sustainability: earthly, analytical, precautionary, action and collaborative. Core problems and cross cutting issues of the 21 centuries. Global, regional, and local environmental issues. Resource degradation, climate change, and desertification.

UNIT II SUSTAINABILITY PRINCIPLES AND FRAMEWORK 9

Our common future - Stockholm to Rio plus 20. Rio principles of sustainable development. 6 R concept. Precautionary and polluter pays principle. Role of civil society, business, and government. Natural step - peoples earth charter – business charter for sustainable development. UN global compact – agenda. Quality of life - poverty, population, and combating poverty.

UNIT III SUSTAINABLE PRACTICES **9**

Investing in natural capital - agriculture, forests, fisheries. Food security and nutrition. Water and sanitation. Ecotourism - biodiversity conservation and ecosystem integrity. Urbanization and sustainable cities – green buildings - sustainable transportation – sustainable consumption and production – sustainable mining - sustainable energy – safeguarding marine resources. Sustainable education and sustainable agriculture.

UNIT IV ASSESSING PROGRESS AND WAY FORWARD **9**

Sustainability in global, regional, and national context. Measuring sustainability - performance indicators of sustainability and assessment mechanism. Human development index - limitations of GDP - human development report. National initiatives for sustainable development - national sustainable development strategy planning. Hurdles to sustainability – operational guidelines – science and technology for sustainable development. Inclusive green growth and green economy.

UNIT V AIR, WATER AND NOISE POLLUTION **9**

Air pollutants: primary and secondary pollutants, automobile pollutants, industrial pollution, ambient air quality standards. Analysis of air pollutants-sulfur dioxide-nitrogen dioxide, carbon monoxide, oxidants, and ozone. Water pollutants: contaminants in water, nitrates, fluorides, detergents, taste and odor, radio activity in water. Major pollutants of water, water quality requirement for different uses, global water crisis issues. Noise pollutants: frequency and sound levels. Effects of noise and occupational health hazards.

TOTAL PERIODS: 45

OUTCOMES: At the end of this course, the students will be able to:

CO#	Course Outcome	Level
CO1	Understanding the basics of sustainability and development challenges.	U : K2
CO2	Summarize the sustainability principles and framework.	U : K2
CO3	Describe the sustainable and green manufacturing practices.	U : K2
CO4	Explain the practical ways of following the sustainability approaches.	U : K2
CO5	Examine the impact of air, water, and noise pollutions on environment	U : K2

CO/PO & PSO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	1		3	3	3	1
CO2	1		3	3	3	1
CO3	1		3	3	3	1
CO4	1	1	3	3	3	1
CO5	1	1	3	3	3	1

REFERENCES:

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3. Dornfield David, Green Manufacturing, Springer, 2012.
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6. United Nations Energy Program, Towards a Green Economy: Pathways to Sustainable Development and Poverty, 2011.

SRI SIVASUBRAMANIYA NADAR COLLEGE OF ENGINEERING

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Kalavakkam – 603 110

ACADEMICS

1.2 **Published Sustainability Course Listings**

Submitted to

The Sustainability Tracking, Assessment & Rating System (STARS)

1.2: Published sustainability course listings

The sustainability related course was published in the Institution website. For comprehensive insights into the modules and learning outcomes please refer to the full course description available through the provided link.

- URL to a public listing of sustainability-focused or sustainability inclusive course descriptions, or syllabus.
  https://www.ssn.edu.in/wp-content/uploads/2024/02/1.1.1_Link_Curriculum-and-Syllabus-signed.pdf

SRI SIVASUBRAMANIYA NADAR COLLEGE OF ENGINEERING

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ACADEMICS

1.3 Support for Academic Staff to Integrate Sustainability into Curriculum

Submitted to

The Sustainability Tracking, Assessment & Rating System (STARS)

1.3 : Support for academic staff to integrate sustainability into curriculum

- Narrative/URL providing an overview of the incentives provided for individual academic staff to integrate sustainability into the curriculum. Research Incentive policy attached

https://www.ssn.edu.in/wp-content/uploads/2024/02/3.1.2_Institution-provides-seed-money-for-research.pdf

- Narrative providing an overview the institution's sustainability-focused community of practice, sustainability across the curriculum training program, or equivalent support program.

1. Faculty Development Program on **Green and Sustainable technology for next generation** was conducted by the Department of Chemical Engineering from 19.3.24 to 25.3.24. The main aim of this FDP is to create awareness on green chemical technology and applications for sustainable development in the chemical industry. Green technology promotes interdisciplinary research and development to important technological and theoretical developments in various environmental related issues.

2. Faculty were encouraged to carry out the interdisciplinary project and grants were provided to them by the college to carryout in the area of sustainability.

One such project is as follows:

DESIGN AND DEVELOPMENT OF BIOSIGNAL CONTROLLED PROSTHETIC HAND
Abstract

According to the Amputee Coalition of America, there are 3 million amputees in the world. Despite the current technological endeavors, most devices used as prosthetics only offer a single degree of freedom. The motivation impelling the project is to develop prosthetic hand that provides maximum dexterity through automated mechanism and motors which are controlled by a remote. Amputation is the removal of any extremity by trauma, surgery, or medical illness. It is also done as a measure to control gangrene or any kind of malignancy. Arm amputations usually are classified according to the region of removal. They are usually designated as digit amputation, metacarpal amputation, wrist disarticulation, forearm articulation or elbow disarticulation. Current prosthetics working on myoelectric controlled prosthetics provide limited functionality. Hence, this project focuses on developing a remote-controlled servo motor-based prosthetic with maximum functionality and degree of freedom.

Main objectives of the project are,

1. Design of lightweight assistive, low-cost prosthetic hand up to wrist with load bearing capabilities.
2. Optimal material identification for the device.
3. Fabrication of hand modules with actuations.
4. Integration of the physiological control signal and the prosthetic arm.

5. Enhanced endurance of the prosthetic arm by controlling through neuro and muscular signals.
6. To implement the control mechanism for operation of the prosthetic hand.
7. To choose appropriate motor that allows the required degree of freedom.
8. Device validation through performance analysis procedures.

International Level
Faculty Development Programme
on
"***Green and Sustainable Technology for Next Generation***".

March 19 - 25, 2024

Convener:

Dr.K.Sathish Kumar
Professor & Head

Co-ordinators:

Dr. R Anantharaj
Dr. D. Balaji
Dr. D Gnana Prakash

Organized by

Department of Chemical Engineering
Sri Sivasubramaniya Nadar College of Engineering
Rajiv Gandhi Salai (OMR), Kalavakkam – 603 110,
Chennai, Tamil Nadu, India.
www.ssn.edu.in

About Institution : Sri Sivasubramaniya Nadar College of Engineering (SSN CE), an autonomous institution affiliated to Anna university, founded by Dr. Shiv Nadar, Chairman of HCL Technologies, is a philanthropic venture to give back to the society that nurtured him. SSN CE is accredited by NAAC with A++ grade. NBA, AICTE, New Delhi has accredited 7 UG and 4 PG programs. SSN CE is one of the top educational institutions in the country and becomes an autonomous institute in the year 2018. Some of the salient features of SSN are: Ranked 45th in Engineering Category and 80th among all educational institutions in India Rankings 2023 by NIRF, MHRD; the state-of-the-art infrastructure with over 1.8 million square feet of buildings; Spacious hostels, sports facilities and faculty quarters within the campus; A student body of 4300+ students, 500+ PhD scholars and 280+ faculty members.

About Department: The Department of Chemical Engineering was started in the year 2004. An area of 5400 sqm is dedicated to our department. The department currently offers B. Tech, in Chemical Engineering, M.Tech in Environmental Science and Technology and PhD program. The department has well-established laboratories. The department promotes research in areas like Natural product extraction, Nanotechnology, green solvent, carbon dioxide sequestration, biosorption, CFD, algal biofuels etc. Many of the students actively participate in research and publish papers in reputed journals.

About FDP – GSTNG :This Faculty Development Program is intended to provide opportunities for Faculty and researchers employed in AICTE approved institutions for upgrading their knowledge and acquiring practical skills in the field of "***Green and Sustainable Technology***". The objective of the programme is to help the participants learn the principles of Separation Technology and understand how to extract and isolate value-added chemicals from their resources without affecting their physical, chemical, biological properties. The FDP will equip them to use "***green solvents***" for various chemical and its allied industrial tasks and expose them to the challenges in the development of new ***green and sustainable technology*** research. The programme includes hands-on Molecular Simulations and Quantum Chemical Calculations.

Topics to be Covered : (1) Emerging Separation Technologies for Clean Air, Water and Energy. (2) Green Solvent-based Carbon Capture and Gas Separations. (3) Adsorbent Materials for Carbon Capture and Gas Separations. (4) Advanced Separations for Hydrogen Energy and (5) Emerging Contaminants Removal and Separation.

Resource Persons : Separation technologist, researchers and practitioners from premier educational institutions and industries will share their expertise.

Registration Fees :

Industry Delegate	: Rs. 1500/-
Academician/ Research Scholar	: Rs. 1000/-
Foreign Delegate	: $ 50

*Registration Link for payment : https://rzp.io/l/FDP-GSTNG.

The number of participants is limited (***Max.25***), and the selection is on a *first-come-first-served basis*. Applications will be processed as and when they are received, and selection will be intimated within 3 working days.

Accommodation :

On request accommodation for delegates can be arranged in Hostels and Guest Houses '***on chargeable basis***'. Request for preferred accommodation should be sent well in advance.

Delegates can avail the transport facilities of the college. For details, visit our college website www.ssn.edu.in.

Address for Communication:

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SSN COLLEGE OF ENGINEERING
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APPROVED STUDENT CONSORTIUM PROJECT - 2018

No	Name and Year of the Students	Project Guide(s) & Department(s)	Title of the Project	Duration	Budget and Items Approved
1	**D. Sutheshnna** (BME - III Year) **M. B. Venkatesh** (Mechanical - II Year) **M. Roshan** (Mechanical - II Year)	**Dr. A. Kavitha** BME **Dr. S. Suresh Kumar** Mechanical **Ms. R. Nithya** BME	Design and development of biosignal controlled prosthetic hand	2 Years	**Budget:** Rs.9.5 lakh **Items Approved** 1. 3D Printing Machine 2. Consumables 3. Testing 4. Miscellaneous