Course Structure and Evaluation Scheme

SYLLABI

M. Tech. Energy and Environment

(A Multi-Disciplinary Program Administered by Department of Chemical Engineering)

Department of Chemical Engineering

School of Chemical Technology, HBTU

Kanpur 02

(BoS Meeting Held on 1st August 2024)

M. Tech (Energy and Environment)
Tentative list of courses

The proposed programme would be in line with the existing M.Tech ordinances. The list of courses is given below:

Proposed Course Structure and Evaluation Scheme for the proposed M.Tech

Semester I

Sr. No	Course Code	Course Type	Course Name	Total Credits	Sessional Marks				ESE	Total Marks
					MSE	TA	Lab	Total		
1	NCH 513	PCC	Heat Transfer Operations	**4 [3, 1, 0]**	**30**	**20**		**50**	**50**	**100**
2	NME 531	PCC	Thermal Power Plant	**4 [3, 1, 0]**	**30**	**20**		**50**	**50**	**100**
3	NCE 509	PCC	Environmental Impact Assessment	**4 [3, 1, 0]**	**30**	**20**		**50**	**50**	**100**
4	NEE 515/ NBE 521/ NCY 561	PEC	Elective I	**4 [3, 1, 0]**	**30**	**20**		**50**	**50**	**100**
Total credits (1st semester)				**16**						

Elective-I

NEE 515 Power Generation, Transmission and Distribution (EE)
NBE 521 Biological Waste Treatment (BE)
NCY 561 Smart Materials for Energy and Environment (Chemistry)

Semester II

Sr. No	Course Code	Course Type	Course Name	Total Credits	Sessional Marks				ESE	Total Marks
					MSE	TA	Lab	Total		
1	NCH516	PCC	Hydrogen Energy and Fuel Cell Technology	**4 [3, 1, 0]**	**30**	**20**		**50**	**50**	**100**
2	NME532	PCC	Energy Storage Systems	**4 [3, 1, 0]**	**30**	**20**		**50**	**50**	**100**
3	NEE 516	PCC	Electrical Energy Conversion and Auditing	**4 [3, 1, 0]**	**30**	**20**		**50**	**50**	**100**
4	NCE 502/ NBE 504/ NOT 508	PEC	Elective II	**4 [3, 1, 0]**	**30**	**20**		**50**	**50**	**100**
Total credits (2nd semester)				**16**						

Elective-II

NCE 502 Design of wastewater treatment systems (Civil)
NBE 504 Bio Energy (BE)
NOT 508 Bio Fuels (OT)

Semester III

Sr. No	Course Code	Course Type	Course Name	Total Credits	Sessional Marks				ESE	Total Marks
					MSE	TA	Lab	Total		
1	NCH 601/ NME 641/ NME 643	PEC	Elective III	**4 [3, 1, 0]**	**30**	**20**		**50**	**50**	**100**
2	NCH 605/ NME 645/ NPH 621	PEC	Elective IV	**3 [3, 0, 0]**	**30**	**20**		**50**	**50**	**100**
3	NCH 611	PCC	Seminar	**1 [0, 0, 2]**	**30**	**20**		**50**	**50**	**100**
4	NCH 613	PCC	Dissertation -I	**8 [0, 0, 16]**	**30**	**20**		**50**	**50**	**100**
Total credits (3rd semester)				**16**						

Elective-III
NCH 601 Plant Safety Hazard and Risk Assessment (CH)
NME 641 Solar Energy Utilization (ME)
NME 643 Wind Energy and Hydro Power (ME)

Elective-IV/ Open Elective:
NCH 605 Waste to Energy (CH)
NME 645 Thin Film Technology (ME)
NPH 621 Nanomagnetism and Sensor Technology (PHY)

Semester IV

Sr. No	Course Code	Course Type	Course Name	Total Credits	Sessional Marks				ESE	Total Marks
					MSE	TA	Lab	Total		
1	NCH 604	PCC	Dissertation II	**16 [0, 0, 32]**	**30**	**20**		**50**	**50**	**100**

NCH 613 Dissertation will have Internal Evaluation while NCH 604 Dissertation will have External Evaluation**.**

Heat Transfer Operation

Assessment: Sessional: 50 marks

L	T	P	C
3	1	0	4

End Semester: 50 marks

Course objective:

The objective of this course is to equip students with a comprehensive understanding and practical skills in analyzing and solving heat transfer problems involving conduction, convection, radiation, and heat exchanger design.

Course outcomes: At the end of the course, the student will be able to

CO1	Analyze and solve complex heat conduction problems involving one-dimensional and multidimensional steady-state and transient conditions using appropriate methods and principles.	Remember Apply,
CO2	Apply boundary layer theory, conservation equations, and dimensional analysis to analyze laminar and turbulent flows and evaluate forced and free convection mechanisms.	Understand, Apply,
CO3	Understand and apply the mechanisms of heat transfer involving phase change to design and analyze systems involving boiling and condensation.	Understand, Apply,
CO4	Analyze thermal radiation heat transfer by applying radiation laws and principles to solve problems involving black and grey surfaces.	Understand, Apply
CO5	Develop the ability to design various types of heat exchangers, including double pipe and shell-and-tube, using fundamental design methods, while considering factors such as fouling, thermal and hydraulic performance, and process integration through pinch design methods	Apply, Analyze, Create

Course Articulation Matrix:

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

Unit I Heat Conduction **Lecture 10**

Fourier's law, thermal conductivity of matter, One-dimensional steady-state conduction through plane wall, cylinder and sphere, conduction with thermal energy generation, heat transfer from extended surfaces, radial fins and fin optimization; Multidimensional-dimensional steady-state heat conduction; Transient Conduction – lumped capacitance method and its validity, plane wall and radial systems with convection, semi-infinite solid, muti-dimensional transient heat conduction.

Unit II Heat Convection **Lecture 8**

Boundary layers concepts, laminar and turbulent flows, conservation equation, no dimensional analysis, boundary layer equations, Reynolds analogy for turbulent flows; Forced convection inside tubes and ducts–correlations for laminar and turbulent forces convection; Forced and free convection.

Unit III Heat Transfer with Phase Change **Lecture 6**

Nucleate, film and pool boiling, boiling in forced convection; Filmwise and dropwise condensation; Heat pipes.

Unit IV Thermal Radiation **Lecture 8**

Fundamental concepts, radiation intensity and its relation to emission, irradiation and radiosity, blackbody radiation, Planck distribution, Wien's displacement law, Stefan-Boltzmann law, surface emission, surface absorption, reflection, and transmission, Kirchoff's law, View factor, emissivity, radiation between black surfaces and grey surfaces.

Unit V Heat Exchanger Design and Analysis **Lecture 8**

Classification of heat exchangers; Basic design methods, LMTD, effectiveness-NTU method; fouling in heat exchangers; Double pipe heat exchangers: Thermal and Hydraulic design; Fundamentals of two phase heat transfer; Shell and Tube Heat exchangers: Basic design procedure, Heat exchanger Network (HEN) and process integration; Pinch design method.

Suggested Text Books

1. "Heat transfer principles and applications" Dutta, B.K., PHI
2. March, Linnhoff. "Introduction to Pinch Technology." Targeting House, Gadbrook Park, Northwich, Cheshire, CW9 7UZ, England (1998).
3. "Heat Transfer" Holman J.P., 9th Ed., McGraw Hill.
4. Kreith, F. and Bohn, M. S., "Principles of Heat Transfer", 6th Ed.,
5. "Fundamentals of Heat and Mass Transfer, Roy, G. K., 5th Ed., Khanna Publishers, Delhi, 2011.

Suggested reference Books

6. Heat and Mass Transfer Fundamentals and Applications, Cengel, Y. A., Ghajar, A. J., 5th Ed., McGraw Hill, Chennai, 2016.
7. Process Heat Transfer, Kern, D. Q., Tata McGraw Hill, New Delhi, 2000.

8. Incropera F.P. and Dewitt D.P, “Fundamentals of Heat and Mass Transfer”, 5th Ed., John Wiley. 2001

Thermal Power Plant

NME 531

Assessment: Sessional: 50 marks

End Semester: 50 marks

L	T	P	C
3	1	0	4

Prerequisite: Fundamentals of Thermodynamics

Course Objectives: This course aims to equip students with a comprehensive understanding of modern power generation techniques, including thermal and nuclear power plants, and their economic considerations.

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

CO1	Understand energy sources, thermodynamic cycles, and modern thermal power plant layouts and site selection	Understand, Remember
CO2	Analyze and improve the performance of Carnot and Rankine steam cycles with reheating and regeneration.	Analyze, Apply
CO3	Explain the components and systems of diesel power plants, including fuel, cooling, lubrication, exhaust, and starting/stopping.	Apply
CO4	Understand nuclear reactions, reactor types, and components, and address nuclear waste disposal and the status of Indian nuclear plants.	Understand, Apply
CO5	Analyze power generation economics, including load factors, cost, and tariffs, to optimize power plant performance and operations	Analyze, Design

Course Articulation Matrix

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

Unit 1: Introduction, Boiler and Accessories

Introduction: Power and energy, classification of sources of energy, review of thermodynamic cycles related to power plants, General layout of modern thermal power plant, Site selection, and Present status of power generation in India.

Boilers & Accessories: Introduction, Classification of Boilers, Comparison Between Fire-Tube and Water-Tube Boiler and Their Comparision, Selection of a Boiler, Boiler Terms, High-Pressure Boilers, Boiler Mountings, Accessories, Draught (Natural and Artificial), Chimney Height and

Diameter, Condition for Maximum Discharge Through a Chimney, Efficiency of a Chimney, Draught Losses, Boiler Efficiency.

Unit 2: Analysis of Steam Cycle: Carnot cycle, limitations of Carnot cycle, Rankine Cycle – performance – thermodynamic analysis of cycles, cycle improvements, Regeneration, regeneration feed water heating, feed water heaters, the typical layout of the steam power plant. Numerical problems.

Unit 3: Diesel Power Plant:

Essential components of diesel power plant, Different systems like fuel supply system, Engine cooling, system, Engine lubrication system, Exhaust system, Engine starting and stopping system. Diesel Power Plant-Introduction – IC, Engines, types, construction– Plant layout with auxiliaries – fuel supply system, air starting, equipment, lubrication and cooling system – super charging.

Unit 4: Nuclear Power Plant

Nuclear fusion and fission, Chain reaction, Nuclear fuels, Components of nuclear reactor, Classification of reactors, Pressurized water reactor, Boiling water reactor, Gas cooled reactor, CANDU reactor, Fast breeder reactor, Nuclear waste and its disposal, Nuclear power plants in India.

Unit 5: Economics of Power Generation

Load curves, Load duration curves, Connected load, Maximum load, Peak load, base load and peak, load power plants, Load factor, Plant capacity factor, Plant use factor, Demand factor, Diversity, factor, Cost of power plant, Performance and operating characteristics of power plant, Tariff for electric energy.

Textbooks:

1. Power Plant Engineering, by R.K. Rajput, Laxmi Publications, 2017, **ISBN:** 978-8131802559.
2. Power Plant Engineering, by P.K. Nag, McGraw Hill Education, 2014**, ISBN:** 978-9339204044
3. Power Plant Engineering, Domkundwar, Arora, and Domkundwar, Dhanpat Rai & Co. Pvt. Ltd., 2016, ISBN: 978-9384378340

Reference Books:

1. Power Plant Technology, M.M. El-Wakil, McGraw Hill Education, 1984 ISBN: 978-0070320377
2. Power Plant Engineering, A.K. Raja, Amit Prakash Srivastava, Manish Dwivedi, New Age International Publishers, 2006, ISBN: 978-8122420734
3. Steam and Gas Turbines and Power Plant Engineering, R.Yadav, Central Publishing House, 2011, ISBN: 978-8190851737

Environmental Impact an Assessment

NCE 509

Assessment: Sessional: 50 marks

End Semester: 50 marks

L	T	P	C
3	1	0	4

Course Objectives: In this course, the students are exposed to learn the need, methodology, documentation and usefulness of environmental impact assessment and to develop the skill to prepare environmental management plan.

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

CO1	To understand the concept, identify the objectives and scope of EIA	Understand, Remember
CO2	To understand the different methods and instruments used to develop an EIA	Analyze, Apply
CO3	To apply various methods for predicting the Environmental impacts of project based on different environmental attributes	Apply
CO4	To evaluate the different alternatives by examining the benefits and drawbacks of them	Evaluate Apply
CO5	Illustrate the necessity of public participation in EIA studies and to evaluate environmental problems affecting the different EA practices.	Analyze, Evaluate

Course Articulation Matrix

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

Syllabus

Unit 1 Basic concept of EIA:

Definition, Concept of sustainable development, Planning and management of impact studies Basic concept of EIA and Methodologies: Initial environmental Examination, Elements of EIA, factors affecting EIA Impact evaluation and analysis, preparation of Environmental Base map, Classification of environmental parameters.

Unit 2 E I Methodologies:

Methods of Impact identifications: Interaction-Matrix method, network methods, checklist methods Description of environmental setting (affected environment) Conceptual framework, Selection process- site visits, interdisciplinary team discussions, scoping; documentation, data sources. Environmental indices and indicators for describing the affected environment- media index for water quality, noise, ecological sensitivity and diversity, archaeological resources and quality of life, development of indices

Unit 3 Prediction and Assessment of Impact:

Prediction and assessment of impacts on the: air, surface water, groundwater, soil, noise environment, biological environment, archaeological environment, visual impacts, socioeconomic environment

Unit 4

Decision methods for evaluation of alternatives: basis of tradeoff analysis, weighting of decision factors, scaling, rating, ranking, development of decision matrix, case studies, current trends, selection of methodology

Unit 5

Public participation in environmental decision making, Preparation of written document, environmental monitoring, Introduction to Environmental Impact assessment statement for various Industries-distillery, textile, tannery and pulp and paper

Environmental Audit: objectives of Environmental Audit, Audit protocol, stages of Environmental Audit, on-site activities, Evaluation of Audit data and preparation of Audit report

Text Books

1. Larry, W. Canter (2555). „Environmental Impact Assessment" McGraw Hill, Civil Engineering Series, 2n edition, Singapore
2. Anjanayelu, Y. (2552). "Environmental Impact Assessment Methodologies", B.S. Publishers, Hyderabad
3. R.R. Barthwal. (2512). "Environmental Impact Assessment.", New Age International (P) limited publisher, New Delhi

Reference Books:

1. Environmental Impact Analysis Handbook – by Rau Whooten; McGraw Hill publications
2. Environmental Impact Assessment – by Larry Canter; McGraw Hill publications
3. Environmental Impact Analysis – A Decision Making Tool by R K Jain
4. Handbook of Environment Impact Assessment by Judith Petts; McGraw Hill publications

Hydrogen Energy and Fuel cell Technology

L	T	P	C
3	1	0	4

Assessment: Sessional: 50 marks

End Semester: 50 marks

Course objectives:

- To create awareness about alternate clean fuel available
- To familiarize the students with the concepts and chemistry of fuel cell

Course outcomes: At the end of the course, the student will be able to

CO1	Understand the fundamentals of hydrogen as a source of energy, including its physical and chemical properties, and the associated issues and concerns	Remember, Understand,
CO2	Gain knowledge about various hydrogen production methods and storage options, and understand the safety and management of hydrogen	Understand, Apply,
CO3	Learn the types, principles, and performance aspects of fuel cells, including a comparison with batteries	Remember, Understand, Analyse,
CO4	Analyze the performance metrics and operational schemes of different fuel cell types, with a focus on PEMFC and DMFC	Remember, Understand, Evaluate
CO5	Apply the knowledge of fuel cell systems to design and develop energy systems for automotive and portable applications.	Understand, Create

Course Articulation Matrix:

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

Unit I Hydrogen – Fundamentals **Lecture 5**

Hydrogen as a source of energy, physical and chemical properties, salient characteristics, relevant issues and concerns

Unit II Hydrogen Storage and Applications **Lecture 10**

Production of hydrogen, steam reforming, water electrolysis, biological hydrogen production, photo dissociation, direct thermal or catalytic splitting of water, hydrogen storage and transportation options, compressed gas, liquid hydrogen, chemical storage, safety and management of hydrogen, applications of hydrogen

Unit III Fuel Cells- Types **Lectures 8**

Brief history, principle, working, thermodynamics and kinetics of fuel cell process, types of fuel cells; AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits, performance evaluation of fuel cell, comparison of battery vs fuel cell

Unit IV Fuel Cell Performance **Lectures 10**

Stoichiometric coefficients and utilization percentages of fuels and oxygen, mass flow rate calculation for fuel and oxygen in single cell and fuel cell stack, total voltage and current for fuel cells in parallel and serial connection, over-potential and polarizations, DMFC operation scheme, general issues-water flooding and water management, polarization in PEMFC

Unit V Designing and Applications of fuel cell **Lectures 7**

Fuel cell systems analyse: Energy systems - power - Train or Drive - Train Analysis -

PEMFC powered Bus - Flow Sheet and conceptual Design-Detailed Engineering Designs, automotive applications, portable applications

TEXT BOOKS:

1) Larminie J. Fuel Cell Systems Explained. John Wiley &Son, Inc google schola. 2003; 3:61-9.

2) Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma

3) O'hayre R, Cha S-W, Colella W, Prinz FB. Fuel cell fundamentals: John Wiley & Sons; 2016.

REFERENCES:

4) Basu S. Fuel cell science and technology: Springer; 2007.

5) Bard AJ, Faulkner LR, White HS. Electrochemical methods: fundamentals and applications: John Wiley & Sons; 2022.

6) Viswanathan, B and M Aulice Scibioh, Fuel Cells – Principles and Applications, Universities Press

Energy Storage Systems

NME532

L	T	P	C
3	1	0	4

Assessment: Sessional: 50 marks

End Semester: 50 marks

Prerequisite: Fundamentals of Thermodynamics

Course Objectives: This course explores key energy storage technologies, including batteries, thermal, and mechanical systems, focusing on their operation, applications, and challenges. Ideal for anyone looking to understand or innovate in sustainable energy storage.

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

CO 1. Understand the fundamentals, applications, and development perspectives of various energy storage systems, focusing on both grid-connected and off-grid applications.
CO 2. Analyze the principles, efficiency, and advancements in thermal storage technologies for large and medium-scale operations.
CO 3. Evaluate the principles, challenges, and technological advancements in mechanical and electrochemical storage systems.
CO 4. Understand the principles, challenges, and technological developments in fuel cells, hydrogen storage, and magnetic storage.
CO 5. Analyze the principles, fabrication techniques, and emerging technologies in electro-optic, optical storage, and supercapacitors.

SYLLABUS:

Unit 1:

Introduction to 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.

Unit 2:

Thermal storage: Thermal properties of materials, Principle of operations, Efficiency factors, large scale and Medium scale operations, Pros and Cons. Advances in thermal storage.

Unit 3:

Mechanical Storage: Types of systems, Principle of operations, Emerging advances and Technologies. case study: Flywheel

Electrochemical Storage: Materials, Principle of Operation, Challenges and research survey, Positive electrode materials, negative electrode materials, electrolytes.

Unit 4:

Fuel Cells and Hydrogen storage: Principle of operation, challenges and Case studies.

Magnetic storage: Principle of operation, emerging challenges, devices and technology review

Unit 5:

Electro-optic and Optical storage: Principles of operation, device fabrication, emerging devices and upcoming technologies

Supercapacitors: Principle of operation, device fabrication, challenges and technical review

Textbooks:

1. Energy Storage: Fundamentals, Materials and Applications, by Robert A. Huggins, Springer, 2010, **ISBN:** 978-1441910233
2. Thermal Energy Storage: Systems and Applications by Ibrahim Dincer, Marc A. Rosen, Wiley, 2021, **ISBN:** 978-1119713158
3. Electrochemical Energy Storage, by Rüdiger-A. Eichel, Falko Schappacher, Jurgen Garche, Springer, 2022, **ISBN:** 978-3662624536

Reference Books:

1. Hydrogen Storage Technologies, by Agata Godula-Jopek, Wiley, 2012, ISBN: 978-3527333424
2. Supercapacitors: Materials, Systems, and Applications, by Francois Beguin, Elzbieta Frackowiak, Wiley-VCH, 2013, **ISBN:** 978-3527331536
3. Energy Storage 2010th Edition by Robert Huggins (Author)

Electrical Energy Conservation and Auditing

NEE 516

L	T	P	C
3	1	0	4

Assessment: Sessional: 50 marks

End Semester: 50 marks

OBJECTIVE:

The objective of this course is to make students learn in the area of electrical energy conservation and auditing. The course includes: Basic Energy scenario, concepts of Energy management, Electricity tariffs and various methods of improving energy efficiency.

Prerequisites: Engineering Mathematics, Engineering Physics, Introduction to Electrical Engineering.

Course Outcomes:

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

CO1	Understand the energy scenario and importance of Electrical energy conservation.	K1, K2
CO2	Understand the concepts of energy management.	K3, K4
CO3	Analyze the Electricity tariff, load management related to Electrical systems.	K4, K5
CO4	Understand the methods of improving energy efficiency in different Electrical systems.	K2, K5
CO5	Understand the concepts of different energy efficient devices.	K2, K4, K6

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

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

Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

SYLLABUS:

Module -1: Energy Scenario (8 Hours):

Introduction and Motivation for Energy Conservation, Principles of Energy Conservation, Energy Conservation in Industries, Energy Conservation in Electrical Generation, Transmission and Distribution, Energy conservation Act-2001 and its features.

Module-2: Basics of Electrical Energy and its various forms (8 Hours):

Electricity tariff, load management and maximum demand control, Thermal Basics-fuels, thermal energy contents of fuel, temperature & pressure, heat capacity, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.

Module-3: Energy conservation in Electrical Systems (8 Hours):

Energy saving opportunities in electric motors, Energy conservation by VSD, Energy conservation in electric furnaces, ovens and boilers., lighting techniques – Natural , CFL, LED lighting sources and fittings.

Module-4: Energy efficiency in Electrical systems (8 Hours):

Electricity billing, energy saving opportunities with energy efficient motors, Electricity Act-2003, Renewable energy Act 2015, Case studies of implemented energy cost optimization projects in electrical utilities.

Module-5: Energy Audit (8 Hours):

Aim of Energy Audit, Energy Flow Diagram, Strategy of Energy Audit, Comparison with Standards, Energy Management Team, impact of renewable energy on energy audit recommendations. Instruments for Energy Audit.

Text Books:

1. S. Sivaganaraju, Electric Energy Generation, Utilisation and Conservation, Pearson Publisher, New Delhi.

2. V. K. Mehta, Electrical Power, Khanna and Khanna Publishers, New Delhi.

3. S. C. Tripathy, "Utilization of Electrical Energy and Conservation", McGraw Hill, 1991.

4. Gupta B. R.: Generation of Electrical Energy, Eurasia Publishing House Pvt. Ltd., New Delhi.

Reference Books:

1. S. L. Uppal, Electrical Power, Khanna and Khanna Publishers, New Delhi.

2. Paul O Callaghan, Energy Management, Tata Mcgraw Hill, New Delhi.

3. Success stories of Energy Conservation by BEE, New Delhi.

4. J. Nanda and D.P. Kothari: Recent Trends in Electric Energy Systems, Prentice Hall of India Pvt. Ltd, New Delhi.

Elective I

Power Generation, Transmission and Distribution

NEE 515

L	T	P	C
3	1	0	4

Assessment: Sessional: 50 marks

End Semester: 50 marks

OBJECTIVE:

This course will provide a good understanding to the students in the area of power system. The course includes calculations of Resistance, Inductance, Capacitance of transmission line, power system components, performance analysis of transmission lines, various aspects of insulators and tower of power systems and brief understanding of AC and DC Distribution systems.

Prerequisites: Engineering Mathematics, Introduction to Electrical Engineering.

Course Outcomes

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

CO1	Understand the basic concepts of electrical power generation, transmission and distribution.	K1, K2
CO2	Apply the principles of physical sciences to understand the working of conventional and non-conventional power plants.	K3
CO3	Evaluate the transmission line parameters, sag of an overhead transmission line and string efficiency of insulators.	K5
CO4	Analyze the performance of various types of transmission lines and Distribution systems topologies.	K4
CO5	Illustrate the different types of insulators, underground cables and effect of Corona.	K1, K2

K1 - Remember, K2 - Understand, K3 - Apply, K4 - Analyze, K5 - Evaluate, K6 - Create

Course Articulation Matrix (CO-PO Matrix):

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

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

SYLLABUS

Module No.	Contents	Mapped CO

I	**Conventional and Non-conventional Power Generation:** General layout, working and site selection of thermal power plant, hydroelectric power plant, nuclear power plant and pumped storage plants. Introduction to Non- Conventional Sources, Solar Energy, Wind Energy.	**CO 1** **CO 2**
II	**Transmission Line parameters:** Calculation of resistance, Skin effect, Proximity effect. Calculation of inductance of single phase, three phase lines with symmetrical spacing. Inductance of composite conductor lines. **Capacitance -** Calculation for single phase two wire line, capacitance calculation for 3-phase lines with symmetrical spacing.	**CO 1** **CO 3**
III	**Performance of Transmission Lines:** Classification of lines, Medium Transmission lines - nominal T method, nominal π method and long transmission lines, Ferranti effect. **Sag, Tension Calculations:** Sag and Tension Calculations with equal and unequal heights of towers, Effect of Wind and Ice on weight of Conductor, Numerical Problems.	**CO 1** **CO 3** **CO 4**
IV	**Insulators:** Types, potential distribution over a string of suspension insulators. String efficiency and methods of increasing string efficiency. **Corona:** Phenomena, disruptive and visual critical voltages and corona power loss. **Underground Cables:** Types, material used. Insulation resistance, Grading of cables - capacitance grading and inter sheath grading.	**CO 1** **CO 3** **CO 5**
V	**D.C. Distribution Systems:** Classification of Distribution Systems, Voltage Drop Calculations in D.C Distributors for the following cases: Radial D.C Distributor fed at one end and at the both ends, Ring Main Distributor. **A.C. Distribution Systems:** Voltage Drop Calculations in A.C. Distributors for the following cases: Power Factors referred to receiving end voltage and with respect to respective load voltages.	**CO 1** **CO 4**

References

Text Books

1. J.B.Gupta, Transmission and Distribution of Electrical Power -S.K.Kataria and sons,10th edition, 2012.

2. Dr. S. N. Singh, Electric power generation Transmission & Distribution- PHI learning Pvt Ltd, New Delhi, 2nd Edition, 2010.

Reference Books

1. Mehta, Rohit, et al. Principles of Power System: Including Generation, Transmission, Distribution, Switchgear and Protection, S. Chand, 4th Edition, 2005.
2. Generation, Distribution and Utilization of Electrical Energy, C.L.Wadhwa, New Age International publishers, 6th Edition 2018.
3. I.J.Nagarath & D.P. Kothari, "Power System Engineering", 3e. N.p., McGraw-Hill Education, 2019.

Web Links

1. https://nptel.ac.in/courses/108102047

BIOLOGICAL WASTE TREATMENT

Subject Code: NBE 512

Sessional: 50 marks
End Semester: 50 marks

L	T	P	C
3	1	0	4

Objective: -

The objective of biological waste treatment is to prepare students to learn the fundamentals related to the design of biological treatment systems applied in waste treatment

Course outcome: - On successful completion of the course student will be able to –

CO1	Characterize waste and composition for the design of suitable treatment facility	**Analyze**
CO2	Analyze appropriate biological methods for the treatment of wastewater	**Analyze**
CO3	Evaluate advanced waste water treatment processes	**Evaluate**
CO4	Analysis of biological processing and treatment of solid Waste and sludge management	**Analyze**
CO5	Formulate experimental strategies to identify and solve the biological waste treatment issues	**Evaluate**

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					2						3		
CO2	3					2						3		
CO3	3	3				2						3		
CO4	3	3				2						3		
CO5	3	3	3	2		2						3		
CO6	3	3	2	2		2			2			3		
Total	**3**	**3**	**2.5**	**2**		**2**			**2**			**3**		

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Syllabus

Unit-I: Waste Generation and Characterization

Characterization & Classification of waste –agrobased, forest residues, industrial waste (solid and liquid), municipal solid and liquid waste, plastic waste, biomedical waste, e-waste, etc, (introduction, sources, effects and measurements), Selection of Appropriate Technologies for waste treatment, legislations for waste management.

Unit-II: Processing and Treatment of Wastewater

Aerobic System Biological processes for domestic and industrial wastewater treatments; Aerated lagoon, activated sludge systems, trickling filter, rotating disc reactors; sequential batch reactor. Anaerobic processes: UASB, and hybrid UASB reactors, biotowers.

Unit-III: Advanced wastewater treatment

Introduction, Fluidized bed bioreactors; Membrane bioreactors (MBRs), Moving bed biofilm reactor (MBBR), biological nitrogen removal, denitrification, biological phosphate removal (BPR)

Unit-IV: Processing and Treatment of Solid Waste sludge management

Biological methods for waste processing: Composting: definition, types, process description, design and operational consideration of aerobic composting; process. description, design and operational consideration of anaerobic composting. Sludge Management: Sludge characteristics, production, stabilization; thickening and dewatering; pathogen removal; sludge transformation and disposal methods.

Unit-V Kinetics of biological waste treatment systems and Case Studies

Biokinetic constants and their determination, batch and continuous system. Case studies on biological waste treatment, and waste treatment flow sheet for Textiles – Tanneries – Pulp and paper – metal finishing – Oil Refining – Pharmaceuticals – Sugar and Distilleries.

Reference:

1. “Environmental Engineering” by Peavy & Row

2 “Waste water Engineering: Treatment, Disposal and Reuse”, Metcalf & Eddy, Inc.; Tata McGraw-Hill Publishing Company Ltd., New Delhi.

3. “Water supply and Pollution Control”, Warren Viessman Jr. and Mark J. Hammer; Harper& Row Publishers; New York.
4. Waste water Treatment: Rational Methods of Design & Industrial Practices Rao & Dutta published by Oxford & IBH Publishing Company Private Ltd. II Edison.
5. C. P. Leslie Grady, Glen T. Daigger, Nancy G. Love, Carlos D. M. Filipe. Biological Wastewater Treatment. Co-published by IWA Publishing & CRC Press, 2011.
6. Cleverson Vitorio Andreoli, Marcos von Sperling, Fernando Fernandes. Sludge Treatment and Disposal. IWA Publishing, 2007.
7. Tchobanoglous G., Burton F.L., Stensel H.D., “Metcalf and Eddy Inc.- Waste Water Engineering Treatment and Reuse”, Tata McGraw-Hill, 2017.
8. Arceivala S.J. and Asolekar S.R., “Wastewater Treatment for Pollution Control and Reuse”, 3rd Ed., Tata McGraw Hill, 2007.
9. Sincero A.P. and Sincero G.A., “Environmental Engineering – A Design Approach”, Prentice Hall, 1996.

Smart Materials for Energy and Environment

NCY 561

Assessment: Sessional: 50 marks

End Semester: 50 marks

L	T	P	C
3	1	0	4

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

CO1	Understand the introduction and different approach to synthesis of nanoparticles.	Remember, Apply, Evaluate, Analyze
CO2	Understand the Carbon-based nanomaterials.	Remember, Apply, Evaluate
CO3	Understand the principle and characterization techniques HR-TEM, FE-SEM, XRD and XPS in materials	Remember, Apply, Evaluate, Analyze
CO4	Understand the chemistry of advanced materials.	Remember, Apply, Evaluate, Analyze
CO5	Understand the chemistry of porous materials	Remember, Apply, Analyze

Course Articulation Matrix (CO-PO Matrix):

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

Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Syllabus

Unit I

Introduction and Synthetic Methods:

Historical Perspective; Importance of Materials, Materials for Future; Classification of Materials; Structures of Materials.

Methods: Co-precipitation Method; Precursor Method; Reduction Method; Spray Drying Method; Sol-gel Method; Hydrothermal Method; Chemical vapour deposition (CVD).

(6-8 lectures)

Unit II

Carbon based nanomaterials

Synthesis of nanoparticle semiconductors, nanowires and nanorods; Synthesis, structures and properties of C_{60} and related compounds; Synthesis, structures and applications of single walled (SWNTs), multi-walled (MWNTs) carbon nanotubes.

(6-8 lectures)

Unit III

Characterization Techniques:

Introduction, principal and application of HR-TEM, FE-SEM, XRD and XPS.

(6-8 lectures)

Unit IV

Chemistry of Advanced Materials:

Polymer-clay nanocomposites, Carbon-Carbon and polymer composite. Surface modification of nanomaterials with specific example to metal and metal oxide nanoparticles and their application in environment, sensors, biosensors, catalysis, and in energy sector.

(6-8 lectures)

Unit V

Chemistry of Porous Materials: Introduction, Synthesis of porous materials, metal organic frameworks (MOFs), covalent organic frameworks (COFs), porous organic polymers (POPs) and their applications in environmental and energy applications.

(8-10 lectures)

Recommended Books:

1. West, A. R., Solid State Chemistry and its Application, Wiley India, New Delhi (2007).

2. Smart, L. E.; Moore, E. A., Solid State Chemistry: An Introduction, 4th Ed., CRC Press, New Delhi (2017).

2. Kakani, S. L.; Kakani, A., Material Science, 3rd Ed., New Age International Publishers, New Delhi (2016).

4. Skoog, D. A.; Holler, F. J.; Crouch, S. R., Principles of Instrumental Analysis, 6th Ed., Cengage Learning India, New Delhi (2014).

3. Willard, H. H.; Merritt, L. L.; Dean, J. A.; Settle, F. A., Instrumental Methods of Analysis, 7th Ed., CBS Publisher, New Delhi (2007).

6. Drago, R. S., Physical Methods for Chemists, 2nd Ed., Saunders College Publishing, Florida (1999).

4. Poole, C. P. Jr.; Owens, F. J., Introduction to Nanotechnology, Wiley India, New Delhi (2007).

5. Pradeep, T., Nano: The Essentials-Understanding Nanoscience & Nanotechnology, Tata McGraw Hill India, New Delhi (2017).

Further Reading

1. Rao, C. N. R.; Gopalakrishnan, J., New Direction in Solid State Chemistry, 2nd Ed., Cambridge University Press, Cambridge (1997).

2. Keer, H. V., Principles of the Solid State, 2nd Ed., New Age International Publishers, New Delhi (2017).

3. Braun, R. D.; Introduction to Instrumental Analysis, 2nd Ed., BSP Books, Hyderabad (2012).

4. Hornyak, G. L.; Tibbals, H. F.; Dutta, J.; Moore, J. J., Introduction to Nanoscience and Nanotechnology, CRC Press, Boca Raton (2008).

5. Viswanathan, B., Nanomaterials, Narosa Publishing House, New Delhi (2014).

Elective II

Design of Wastewater Treatment Systems
NCE 502

L	T	P	C
3	1	0	4

Assessment: Sessional: 50 marks

End Semester: 50 marks

Course Outcomes:

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

CO1	Understand the physical, chemical, and bacteriological characteristics of wastewater, water quality standards, and factors affecting BOD rate of reaction.
CO2	Gain knowledge about various wastewater treatment methods, systems, and basic design considerations including flow rates and mass loading.
CO3	Learn the concepts, functions, and design procedures for preliminary and primary sewage treatment units.
CO4	Design secondary and tertiary treatment units for the removal of various contaminants and understand sludge treatment methods.
CO5	Explore advanced technologies for wastewater disposal and understand the layout and concept of sustainable wastewater treatment plants.

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

Unit 1

Introduction: Physical, chemical and bacteriological characteristics of wastewater, water quality standards, Water borne diseases and their control, Composition of wastewater, Factors affecting BOD rate of reaction, population equivalent.

Unit 2

Introduction to Wastewater Treatment and Design
Concept, treatment methods – unit operations and unit processes, treatment systems –preliminary, primary, secondary, tertiary.
Basic Design Considerations: Strength and characteristics of wastewater, flow rates and their functions, mass loading, design criteria

General Procedure for Design Calculations: Objectives, types of treatment units, sizing of units, calculation procedure

Unit 3

Wastewater Treatment

Preliminary and primary sewage treatment: Concept, functions and design of approach channel, equalization basin, screen chamber, grit chamber, primary sedimentation tank.

Secondary treatment of sewage: Principles, functions and design of secondary treatment units – SST, ASP, TF, RBC, Extended aeration – oxidation ditch, aerated lagoon, waste stabilization pond.

Unit 4

Tertiary treatment: Introduction to removal of nitrogen, phosphorous, refractory organic, heavy metal, suspended solids and pathogenic bacteria.

Sludge Treatment: Quantity and characteristics, concept, sludge digestion-aerobic and anaerobic, methods – sludge conditioning, dewatering, composting.

Design of sludge treatment units: Introduction, Treatment concept, Design essentials, Sludge digestion.

Unit 5

Disposal of Wastewater on land and water bodies

Introduction to Duckweed pond, vermiculture and root zone technologies and other emerging technologies like UASB, final polishing unit, River Bank Filtration, Zero valent iron, Phytoremediation, Bioremediation, Sludge drying beds.

Sewage treatment plant layout, concept of sustainable wastewater treatment

Books and References

1. Metcalf Eddy: Wastewater Treatment – Disposal and Reuse, TMH, Fourth Edition, 2017

2. Arceivala, S.J, Asolekar, S.R: Wastewater Treatment for Pollution Control and reuse, TMH, Third Edition, 2007

3. Wesley Eckenfelder: Industrial Water Pollution Control. McGraw Hill, Second Edition, 2000

4. Reynolds and Richards: Unit Operations and Processes in Environmental Engineering, Cengage Learning, Second Edition, 1996

BIOENERGY
Subject Code: NBE 504

Assessment: Sessional: 50 marks

End Semester: 50 marks

L	T	P	C
3	1	0	4

Course Objectives:

- To give an overview of biomass energy source
- To create an understanding on biomass derived fuel system
- To generate understanding on energy utilization of bio-based fuel.

Course Outcome:

On successful completion of the course student will be able to –

CO1	To learn about present energy scenario in the world and importance of alternate energy	Understand
CO2	To understand basics of biofuels, their production technologies and applications in various energy utility routes	Understand
CO3	To understand and evaluate various biomass pretreatment and processing techniques in terms of their applicability for different biomass type for biomass conversion processes	Evaluate
CO4	Able to understand the process of pyrolysis and gasification of biomass: Thermo-chemical conversion	Understand ,
CO5	The student will be capable to explain Biochemical conversion process	Evaluate

Course Articulation Matrix (CO-PO Matrix):

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

Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Syllabus

UNIT I

Introduction: Energy world demand, Bio Energy Resources, World Bio Energy Potential, India’s Bio Energy Potential, Biomass Resources and classification, Physio-chemical characteristics. Energy and fossil fuel use, fossil fuel reserves, sustainable fuel sources. Consequences of burning fossil fuel – effects of industrial (anthropogenic) activity on greenhouse gases, reduction in global greenhouse gases, sequestration of carbon dioxide, alternative energy sources.

Unit II: Bioenergy systems

Current bio-energy applications and conversion technologies, Advantages of applied bioenergy over other sources of energy. Biomass conversion routes: biochemical, chemical, thermochemical and physical processes; Bio- refinery concept: definition; different types of bio-refinery

Unit-III: Biochemical conversion

Aerobic and Anaerobic conversion, Fermentation; Bio-methanation: biogas production mechanism and technology, types of digesters; Design of biogas plants, installation, operation and maintenance of biogas plants, biogas slurry utilization and management, biogas applications; Cost benefit analysis of biogas for cooking, lighting, power g eneration applications, Case studies.

Unit-IV: Biogas Systems

Principle, Design of Bio mass Gasifiers, updraft gasifier, down draft gasifier, zero carbon biomass gasification plants, Gasification of plastic-rich waste. Pyrolysis and Gasification of Biomass: Thermo-chemical conversion of ligno-cellulose biomass for liquid fuel production - Pyrolysis of biomass-Pyrolysis regime, effect of particle size, temperature, and products obtained.

Unit-V : **Biomass and Biofuel**

Biomass composition and energy content; Biofuels, types of biofuels , Biological solid fuels 1^{st}, 2^{nd} and 3^{rd} generation biofuels. Liquid biofuels to replace petrol – methanol production. Large scale ethanol production from biomass, use of lignocellulosic for ethanol production, ethanol extraction after production, use of ethanol as fuel. Liquid biofuel to replace diesel – synthetic diesel(FT synthesis).

Suggested texts and reference materials

1. Ralph E.H. Simsed. (2004); Bioenergy options for cleaner environment by World Renewable Energy Network.
2. Mutha, V. K. (2010). Handbook of bioenergy and biofuel SBS Publishers, Delhi
3. Clark, J. H., & Deswarte, F. (Eds.). (2014). Introduction to chemicals from biomass. John Wiley & Sons. 3. Klass, D. L. (1998). Biomass for renewable energy, fuels, and chemicals.Elsevier.
4. Mukunda, H. S. (2011). Understanding clean energy and fuels from biomass. Wiley India

5. Speight, J. (2008). Synthetic fuels handbook: properties, process and performance. McGraw-Hill
6. Dahiya, A. (Ed.). (2014). Bioenergy: Biomass to biofuels. Academic Press. 8. Hall, D. O., & Overend, R. P. (1987). Biomass: regenerable energy.

BIO FUELS

Subject Code: NOT 508

L	T	P	C
3	1	0	4

Sessional: 50 marks
End Semester: 50 marks

Preamble

This course delves into various types of biofuels, their feedstocks, production processes, refineries and their applications. It emphasizes the environmental impact and sustainability of biofuels as an alternative energy source.

Prerequisite:

Basic understanding of organic chemistry, microbiology, and environmental science.

Course Outcome:

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

CO1	Understanding history and importance of biofuels.	**Remember Understand**
CO2	Analyze the feedstocks used and challenges for biofuel production	**Analyze**
CO3	Assess the role and impact of pre-treatment steps in biofuel production.	**Apply, Analyze**
CO4	Evaluate various conversion processes for biofuel production.	**Analyze, Evaluate**
CO5	Evaluate refineries for production of quality biofuels.	**Evaluate**

Mapping with Program Outcomes:

CO \ PO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	3	2	2	2	3	2	2	2	2	3	2	2
CO2	3	3	2	3	2	3	2	2	3	3	3	3
CO3	2	3	3	2	3	2	3	3	2	3	2	2
CO4	2	2	2	3	2	3	3	3	3	3	2	3
CO5	3	2	3	3	3	2	2	2	3	2	3	3

Syllabus

Module 1

Introduction: World energy scenario, consumption pattern, fossil fuel depletion and environmental issues, History of biofuels, Biofuel Policy

Module 2

Feedstock: Availability and abundance, composition and energy potential, biomass production and selection, biomass as energy resources: dedicated energy crops, annual crops, oil crops. Microalgae as feedstock for biofuels, enhancing biomass properties for biofuels, challenges in conversion

Module 3

Pre-treatment: Barriers in lignocellulosic biomass conversion, pre-treatment technologies such as acid, alkali, auto-hydrolysis, hybrid methods, role of pre-treatment in the bio-refinery

Module 4

Conversion Processes: Physical and Thermal conversion processes, microbial conversion processes, hybrid chemical and biological conversion processes; Types, fundamentals, equipment and applications and fuel properties

Module 5:

Bio- refinery: Basic concept, types of bio-refineries, integrated bio-refinery feedstocks and properties, economics and Life Cycle Analysis, Quality Control measures in biofuels

Reference Books:

1. "Biofuels Engineering Process Technology" by Caye M. Drapcho, John N. Nghiem, and Terry H. Walker.

2. "Handbook of Biofuels Production: Processes and Technologies" edited by Rafael Luque, Carol Sze Ki Lin, and Karen Wilson.

3. "Biofuels: Production, Application and Development" edited by David M. Mousdale.

4. "Introduction to Biofuels" by David M. Mousdale.

5. "Biofuels: Securing the Planet's Future Energy Needs" by W. Scott Dunbar.

6. A.A. Vertes, N. Qureshi, H.P. Blaschek, H. Yukawa (Eds.), Biomass to Biofuels : Strategies for Global Industries, Wiley, 2010.

7. S. Yang, H.A. El-Enshasy, N. Thongchul (Eds.), Bioprocessing Technologies in Biorefinery for Sustainable Production of Fuels, Chemicals and Polymers, Wiley, 2013.

Elective III

PLANT SAFETY HAZARD AND RISK ASSESSMENT
NCH 601

Assessment:

Sessional: 50 marks End

Semester: 50 marks

L	T	P	C
3	1	0	4

Course Objectives: Study of plant safety is an essential requirement providing an overview of the safety regulations and practices, plant hazards and their control, risk assessment and management along with accident analysis. The skills of safety/energy management, audit and risk analysis prepares the plant technical and operating team to emerge to a safe protocol and minimize potential damages to personnel, process equipment and the environment.

Course Outcomes:

Students completing the course will be able to

CO1	Identification of key concepts of safety, hazards, risk assessment and distinguishing typical sources of risk and hazard in a process plant	Understand, Apply
CO2	Develop an understanding/assessing of severity and the consequences of incidents and toxicological aspects	Understand, Analyze, Evaluate
CO3	Undertake a Hazard and Operability Study (HAZOP) for the identification of hazard, chances of occurring and consequences	Understand, Apply, Analyze, Evaluate
CO4	Getting aware about the various government/investigating agency for the analysis of safety related to process, environmental and human reliability and relevant aspects	Understand, Apply
CO5	Understanding the root cause and technical aspects of incidents and generating process design for reliable operations	Understand, Apply, Analyze, Create

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	2	2	-	-	2	-	3
CO2	3	2	1	1	1	2	2	-	-	2	-	2
CO3	3	3	2	1	1	1	2	1	-	2	2	3
CO4	3	3	2	1	2	1	2	1	-	2	1	3
CO5	3	3	2	1	2	3	2	1	-	2	2	3
Avg.	3.00	2.60	1.80	1.00	1.40	1.80	2.00	0.60	-	2.00	1.00	2.80

Module 1 (8 hours)

Introduction, key concepts: Safety, Hazard and Risk, nature of the accident process, inherent safety. OSHA, fatal accident, fatality rate. The accident Process: Initiation, Propagation, and Termination. Review of major chemical industry accidents. Toxicological studies, Dose versus response curves, Relative toxicity, Threshold Limit Values. Storage and handling of flammable and toxic chemicals.

Module 2 (8 hours)

Industrial Hygiene: Regulations, Identification, Evaluation and Control. Safety aspects related to toxicity, noise, pressure, temperature, vibrations, radiation etc. MSDS, source models, fire triangle, flammability characteristics of liquids and vapors, flammability limit estimation, LOC and inerting, ignition energy, auto-ignition, auto-oxidation. VCE, BLEVE, vacuum and pressure purging, static electricity. Explosion proof equipment and instruments.

Module 3 (8 hours)

Identification of reactive chemical hazards, relief concept and types, relief systems, relief sizing. Hazard identification and risk assessment. Hazard and operability study (HAZOP); procedure and application. Probability theory and interaction between process units. Fault tree and event tree analysis. Hazard models and risk data.

Module 4 (8 hours)

Technology and process selection. Process safety strategies, safety reviews and accident investigations, process uncertainties, reliability engineering and economics of loss prevention. Design for process safety. Safety laws and regulations: Agencies involved.

Module 5 (8 hours)

Protections against fire, explosion and toxic hazards. Tackling disasters, plan for emergency. Risk management routines, Emergency shutdown systems, well integrated processes, process design for reliable operations. Introduction to safety audits. Occupational health and safety impacts of different industry sectors.

Suggested Text Books

1. Crowl D. A. and Louvar J. F., Chemical Process Safety: Fundamentals with applications, 3rd edition, Pearson 2014.

2. Lees', Loss prevention in the process Industries, 4th edition, Butterworth-Heinemann, 2012.

Suggested Reference Book

Wells G. L., Safety in Process Plant Design, John Wiley and Sons, 1980

Solar Energy Utilization

NME 641

L	T	P	C
3	1	0	4

Sessional: 50 marks
End Semester: 50 marks

Prerequisite: Course on basic physics, heat transfer and energy generation.

Course Objectives:

This course aims to develop the capability to understand the solar radiation, solar geometry, solar system components and their significance.

Course Outcomes:

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

CO1 Comprehend the Indian energy scenario, basics of solar energy, and testing.

CO2 Understand the structure of solar cells and be able to test and load estimation.

CO3 Design a Solar Thermal/PV system for any requirement.

CO4 Understand the need for storage for solar energy and the selection of materials for solar energy storage.

CO5 Understand the basics of working on different solar energy applications.

Course Content:

Unit 1: Introduction to solar energy resources

Scenario and status of solar photovoltaic technology in India and the World; Solar energy mission, policies and financing, Solar radiation - concepts, assessment and variability, Solar energy data, estimation of solar energy on different planes; principle, characteristics, and types of solar photo-voltaic (PV) cell.

Unit 2: PV performance testing and load estimation

Performance testing of solar PV modules; Monitoring equipment, Load estimation, sizing of array and battery; Types of PV system, isolated and grid connected PV power plants; Installation and maintenance, grid interfacing, field monitoring; economic analysis, cost effective hybrid designs.

Unit 3: Solar Thermal Energy Utilization

Fundamentals of thermal collectors-Basics of heat transfer, Technology and Working principles, Solar flat plate collector, Collector Efficiency, Absorber plate types, Collector loss estimation, Analysis of collector, Concentrating collector, Optical Efficiency, Concentration ratio, Collector configurations, Thermal analysis.

Unit 4: Solar Thermal Storage technologies

Necessity of storage for solar energy: Chemical energy storage, Thermal energy storage: Phase change materials storage, Composite phase change materials storage. Water heating systems: active and passive; Passive heating and cooling of buildings

Unit 5: Applications of solar energy utilization

Solar lanterns, Solar water pumping systems, Solar home lighting application, Remote lighting. Solar distillation; Solar thermal power generation; Solar drying, and Solar cooking.

Text Books:

1. Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI Learning Pvt Ltd, 2015.
2. Sukhatme S.P. and Nayak J.K., "Solar Energy", Tata McGraw Hills, 4th Edition, 2017
3. M. A. S. Malik, G. N. Tiwari, A. Kumar and M.S. Sodha, Solar Distillation. Pergamon Press, New York, 1982.

Reference books:

1. Julian Chen, C., "Physics of Solar Energy", John Wiley, 2011.
2. Duffie, J.A., and Beckman, W.A, "Solar Energy Thermal Process - 4th Edition", John
3. Wiley and Sons, 2013.
4. S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, second edition, Tata McGraw-Hil, New Delhi, 1996
5. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, second edition, John Wiley, New York, 1991
6. D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000
7. M. S. Sodha, N. K. Bansal, P. K. Bansal, A. Kumar and M. A. S. Malik, Solar Passive Building: science and design, Pergamon Press, New York, 1986
8. Tiwari and Tiwari, Handbook of Solar Energy - Theory, Analysis and Applications, Springer, 2016

Wind Energy & Hydro Power Energy

NME 643

L	T	P	C
3	1	0	4

Sessional: 50 marks
End Semester: 50 marks

Prerequisite: Course on basic fluid mechanics and energy generation.

Course Objectives:

This course aims to develop the capability to understand, mathematically model, and analyze the wind and hydropower converters and processes involved in them.

Course Outcomes:

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

CO1	Understand the wind energy generation and energy harvesting from wind energy.
CO2	Understand the workings of different wind energy converters and perform related calculations for their analysis.
CO3	Understand the workings of various wind energy measurement devices and their application for wind energy assessment.
CO4	Understand the working principle of hydropower turbines for different site conditions
CO5	Understand the different types of hydropower plants.

Course Content:

Unit 1: Introduction to wind energy resources

Wind Energy: Global Wind Energy resources, Pressure gradient, and Coriolis forces, Atmospheric boundary layer, Atmospheric stability, Basic concepts of wind energy converter, surface wind characteristics and related parameters, Energy equation

Unit 2: Wind energy conversion devices, principle, and selection

Wind Turbine: Types of wind energy converters or turbines, Different components of the wind turbine, selection of turbine rotors, Electrical system used for electrical power generation, Basic Aerodynamic design principle of the turbine, Commercial application of wind turbine, Wind farms, concept of wind tree and wind pump.

Unit 3: Wind energy measurement and assessment

Measuring instruments for wind energy application Measurement of wind velocity-Anemometer-vane type – cup type, modern instruments, and their principles. Wind data assessment and selection of prospective wind energy sites, Estimation of wind energy.

Unit 4: Hydropower Technology and Selection

Classification and working principles of hydro turbines, different components of impulse and reaction turbines, Design concepts of hydro turbines, pump-as-turbine, and other non-conventional hydro turbines, Characteristics of hydro turbines, geometric similarity, main characteristic, and operating characteristic curves, Selection of hydro turbines based on specific speed and their optimal selection.

Unit 5: Hydropower: Plants and components

Principles of hydropower development: Types, layouts, and component work, surge tanks, types and choice, flow duration curves, and dependable flow, Storage and pondage, Pumped storage plants, Special types of hydel plants.

Text Books:

1. S.M. Muyeen, Wind Energy Conversion systems, Springer
2. Yosif Golfman, Hybrid anisotropic Materials for Wind Power Turbine Blades, CRC Press
3. Hydraulic Machines by Banga & Sharma, Khanna Publishers.
4. Fluid Mechanics and Machinery by D. Rama Durgaiah, New Age International.

Reference books:

1. Manwell J.F., McGowan JG, and Rogers A. L., Wind Energy Explained: Theory Design and application, John Wiley and Sons Ltd., London 2002
2. Fluid Mechanics & Fluid Machines; Dr. R.P. Saini, November, 2022 © AICTE, ISBN: 978-81-959863-6-1
3. Hydraulic Machines: Theory & Design, V.P. Vasandhani, Khanna Pub.
4. C.P. Kothandaraman, R. Rudramoorthy - Fluid Mechanics and Machinery-New Age Publications
5. Hydraulic Machines by D S Kumar, Kataria & Sons
6. Pramod Jain, Wind Energy Engineering, Mc Graw Hill

Elective IV

Waste to Energy

NCH 605

L	T	P	C
3	1	0	4

Sessional: 50 marks
End Semester: 50 marks
Course objectives:

- To create awareness about methods for converting waste to Energy
- To familiarize the students with the concepts and chemistry of Pyrolysis, Gasification Transestification.

Course outcomes: At the end of the course, the student will be able to

CO1	Understand the nature of Waste and energy conversion methods	Remember, Understand,
CO2	Gaining knowledge about Pyrolysis and gasification	Understand, Apply,
CO3	Learn the methods to create the energy from waste	Understand, Analyse,
CO4	Analyze the performance Fuel cell and management of organic Waste	Understand, Evaluate
CO5	Gain knowledge about Fermentation and transestification	Understand, Create

Course Articulation Matrix:

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

Unit I **Lecture 8**

Introduction, Characterization of wastes. Energy production form wastes through incineration, energy production through gasification of wastes.

Unit II **Lecture 8**

Energy production through pyrolysis and gasification of wastes, syngas utilization. Densification of solids and efficiency improvement

Unit III **Lecture 8**

Energy and chemicals production from waste plastics, rubber tyres, gas cleanup.

Unit IV **Lecture 8**

Energy production from organic wastes through anaerobic digestion and fermentation, Introduction to microbial fuel cells.

Unit V **Lecture 8**

Energy production from wastes through fermentation and transesterification. Cultivation of algal biomass from wastewater and energy production from algae.

TEXT BOOKS:

1) Rogoff, M.J. and Screve, F., "Waste-to-Energy: Technologies and Project Implementation", Elsevier Store.
2) Young G.C., "Municipal Solid Waste to Energy Conversion processes", John Wiley and Sons.
3) Harker, J.H. and Backhusrt, J.R., "Fuel and Energy", Academic Press Inc.
4) EL-Halwagi, M.M., "Biogas Technology- Transfer and Diffusion", Elsevier Applied Science.
5) Hall, D.O. and Overeed, R.P.," Biomass - Renewable Energy", John Willy and Sons.
6) Mondal, P. and Dalai, A.K. eds., 2017. Sustainable Utilization of Natural Resources. CRC Press.

Thin Film Technology
NME 645

L	T	P	C
3	1	0	4

Sessional: 50 marks
End Semester: 50 marks

Course Objectives: To provide understating of different thin film deposition methods, thin film properties, theory of thin film formation, film-based devices and applications.

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

CO1	To get acquainted with an overview of thin film technology, different types of thin films, defects and mechanical behavior of thin films.
CO2	Demonstrate the understanding of thin film nucleation and growth kinetics in deposition methods.
CO3	To provide understanding of vacuum systems in thin film deposition methods.
CO4	Demonstrate the understanding of different deposition method with engineering applications.
CO5	To get acquainted with understanding of thin film thickness and topography measurements principles and techniques, understand the different characteristics of thin films and applications.

Unit 1

Need and overview of thin film technology, crystal structures of thin films, polycrystalline, epitaxial and nanocrystalline thin films, various defects in thin films caused by interstitials, dislocations, grain boundaries and vacancies etc. Elastic and Plastic behaviour of thin films.

Unit 2

Introduction to film growth: nucleation and film growth kinetics, thin film growth control, Diffusion, Adsorption and desorption phenomenon. Thin film materials, Physical and chemical thin film deposition methods. Thermal evaporation technique, sputtering, PECVD, Molecular beam epitaxy methos.

Unit 3

Vacuum Science and Technology, Vacuum pumps, construction of vacuum systems, gas kinetics, Maxwell-Boltzmann distribution, mean free path, Knudsen equation. Length Scale Analysis.

Unit 4

Soft lithography techniques, Spin coating, Free Surface Hydrodynamics, Capillarity, Nano imprint Lithography (NIL), Micro Contact Printing (MCP), Micro-Molding, E-beam Lithography, Wet and dry etching processes.

Unit 5

Characterization of thin film: Electron microscopy-ray diffraction, UV-Vis spectrophotometer, transmission electron microscopy (TEM), spectroscopic ellipsometry, quartz crystal microbalance

(QCM), film thickness measurements, film bonding, topography, defects and crystallography, Thin film devices. Applications: Solar cell fabrication, Micro-electro-mechanical systems (MEMS), photovoltaics, integrated circuits, micro-electro-optomechanical systems (MEOMS).

Text books:

1. Introduction to Microelectronic Fabrication 2e by Richard C. Jeager, Prentice Hall,2002.
2. Thin Film Phenomena by K. L. Chopra, McGraw Hill 1969.

Reference Books:

1. Fundamentals of Microfabrication and Nanotechnology by Marc J. Madou, CRC Press, 2011.
2. Materials Science of Thin Films: Depositon and Structure 2e by Milton Ohring. Academic Press Inc, 2001
3. Thin film processes II. Vol. 2. by Vossen, John L., and Werner Kern, Gulf Professional Publishing, 1991.
4. Thin-Film Deposition: Principles and Practice by Donald L Smith, McGraw Hill, 1991
5. Handbook of Thin Film Technology by L. I. Maissel and Glang, McGraw Hill Higher Education, 1970
6. Nanoscale Science and Technology by Robert Kelsall, Ian Hamley and Mark Geoghegan, Wiley, 2007.

Nanomagnetism and Sensor Technology

NCH 601

L	T	P	C
3	1	0	4

Sessional: 50 marks
End Semester: 50 marks

Course Objectives: To provide understating of different thin film deposition methods, thin film properties, theory of thin film formation, film-based devices and applications.

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

CO1 To understand the fundamentals of thin films

CO2 To understand the concept of the growth of the thin films by using various methods.

CO3 To analyze the thickness of the developed thin films by using various methods.

CO4 To learn about the fabrication of sensors including oxide thin films for energy and environment application devices.

CO5 To understand the fabrication of magnetoresistance devices to address the energy consumption during operation.

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12
CO1	3	1	3	1	0	2	1	0	1	2	0	1
CO2	3	1	2	1	0	2	1	0	1	2	0	1
CO3	3	1	3	1	0	2	1	0	1	2	0	1
CO4	3	1	3	1	0	2	1	0	1	2	0	1
CO5	3	1	3	1	0	2	1	0	1	2	0	1

UNIT I
8

Basics of Thin Films: Thin and Thick Films, fabrication methods of thin films, Chemical methods of thin film deposition,chemical vapor deposition, physical vapor deposition methods and requirement of vacuum,thermal evaporation, sputtering, and LASER ablation

UNIT II
7

Nucleation and Growth Mechanism: Various types of growth mechanisms of thin films, nucleation and growth of thin films, post-deposition process, and their outcomes, different types of structural defects, Epitaxial thin films,polycrystalline and amorphous thin films, molecular beam epitaxy, atomic layer deposition

Unit III
7

Thickness Measurement: Measurement of thickness of thin films, Different methods, and instruments for thicknessmeasurements, Quartz crystal monitor, optical, mechanical, electrical, and structural properties ofthin films

UNIT IV
7

Sensors and Device Fabrication: Deposition of various magnetic materials, anisotropy in magnetic thin films, domains in thinfilms, magnetic sensors fabrications, fabrications of Perovskite and oxide thin films, fabricationof tunnel junction devices

UNIT V 7

Tunnel magnetoresistance devices: Spin-dependent tunneling, Tunnel Magnetoresistance (TMR), Effects of Fermi surface, Effect ofinterfacial states, diffusive tunneling, elastic and inelastic tunneling, localized states, Bias voltagedependence of TMR, Magnetic tunnel Junctions (MTJ), Tunnel Junctions with Half Metals.

References

1. K. L. Chopra and S. R. Das, “Thin Film Solar Cells”, Springer, 1983.
2. L. I. Maissel and Glang, “Handbook of Thin Film Technology”, McGraw Hill HigherEducation, 1970.
3. J. C. Anderson, “The Use of Thin Films in Physical Investigation”, Academic Press Inc.,1966.
4. J. J. Coutts, “Active and Passive Thin Film Devices”, Academic Press Inc., 1978.
5. R.W. Berry, P.M. Hall and M.T. Harris, “Thin Film Technology”, Van Nostrand, 1968.
6. S. Blundell, Magnetism in Condensed Matter, 1st edition, Oxford University Press, 2001.