DEPARTMENT OF CHEMICAL ENGINEERING

List of Open Electives Courses offered for other departments

Under R-20 Regulation

Sem-V to Sem-VIII (w.e.f AY 2022-23 onwards)

S.no	Course Code	Course Name	Semester being offered as on date *
1.	20CH O01	Energy Resources and Technology	ODD
2.	20CH O02	Industrial Pollution Control	EVEN
3.	20CH O03	Water Conservation Management	ODD
4.	20CH O04	Environmental and Sustainable Development	EVEN
5.	20CH O05	Safety and Hazards Management	ODD
6.	20CH O06	Fundamentals of Fuel Cells	ODD

*** Kindly note that Our department faculty shall teach these subjects in alternate semester also, if required by any department, as per CBIT elective rules.**

20CH O01 **ENERGY RESOURCES AND TECHNOLOGY**
(Open Elective)

Instruction	3Hours per week
Duration of SEE	3 Hours
SEE	60Marks
CIE	40Marks
Credits	3

Course Objectives: This course will help the students to understand

1. Concept of various forms of Renewable energy resources and Non-Renewable energy resources.
2. Outline division aspects and utilization of renewable energy sources for both domestics and industrial applications.
3. Identify Wind energy as alternate form of energy and to know how it can be tapped.
4. Concepts of thermo and bio-chemical process along with novel technologies to conversion of biomass to Bio fuel.
5. Environmental and cost economics of using renewable energy sources.

Course Outcomes: At the end of the course students will be able to

1. Understand of renewable and non-renewable sources of energy.
2. Explain the use of solar energy and the various components used in the energy production with respect to applications.
3. Design wind turbine blades and know about applications of wind energy for water pumping and electricity generation.
4. Understand the concept of Biomass energy resources and their classification, types of biogas Plants- applications
5. Summarize the knowledge of Ocean energy, tidal energy, and geothermal energy.

CO-PO-PSO Matrix

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

UNIT- I

Introduction: Classification of Energy Resources, Conventional Energy Resources, Non-Conventional Energy Resources, Alternative Energy Resources, World energy status, Current energy scenario in India, Environmental aspects of energy utilization, Energy and sustainable development. Energy policies in India.

UNIT- II

Wood and wood Charcoal, Coal-Classification of coal, products of wood carbonization of Coal and Coal derived fuels, characteristics, production methods and uses. Fuels derived from oil and gases, Characteristics, production methods and uses, Shale oil and Shale gas, Oil sands.

UNIT- III

Solar energy basic concepts, Solar cells, Solar collectors, Solar Thermal Applications-Heating, Cooling, Distillation, Desalination, Drying, Cooking, Solar pumping, Solar photo voltaic systems. Solar PV Applications, Government schemes and policies.

UNIT- IV

Wind energy, Wind energy conversion systems, Site characteristics, Types of wind turbines, Energy from biomass-Biomass resources, Biomass conversion technologies, Bio-gas generation. Factors affecting bio-digestion, Classification of biogas plants Production methods, characteristics, Bio fuels-Bioethanol, Biobutanol, Biodiesel production.

UNIT- V

Other Renewable Sources –Ocean Energy Resources, Principle of OTEC, Tidal energy, Geothermal energy, Hydroelectric Power.

Energy Auditing and Conservation: Short term, medium term, long term schemes, energy conversion, energy index, energy cost, representation of energy consumption, Sankey diagram, energy auditing, Conservation methods in process industries theoretical analysis, practical limitations.

Text Books:

1. B. H. Khan, Non-Conventional Energy Resources, , The McGraw Hill,2013
2. G.D. Rai, Non-Conventional Energy Sources, Khanna Publications, New Delhi, 2011.
3. Kishore V V N, Renewable Energy Engineering and Technology", Teri Press, New Delhi, 2012

Suggested Reading:

1. Twidell, J.W. & Weir, A. Renewable Energy Sources, EFN Spon Ltd., UK, 2006
2. Sukhatme S.P., Solar Energy, Tata McGraw Hill, 1984
3. Freris. L.L., "Wind Energy Conversion Systems", Prentice Hall, UK, 1990.
4. Frank Krieth& John F Kreider ,Principles of Solar Energy, John Wiley, New York

20CH O02 **INDUSTRIAL POLLUTION CONTROL**
(Open Elective)

Instruction	3 Hours per week
Duration of SEE	3 Hrs
CIE	40 Marks
SEE	60 Marks
Credits	3

Course Objectives: This course will help the students to understand the:

1. Effects of pollution on environment and ecosystems
2. Types and sources of pollution
3. Measurement of air and water pollution
4. Different methods and equipment used in pollution abatement
5. Management practices in solid and hazardous wastes.

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

1. Differentiate the types of wastes generated in an industry, their effects on living and non-living things
2. Understand the effect of climate changes, atmospheric dispersion of air pollutants, and operating principles.
3. Understand working principles of particulate control devices.
4. Quantify wastewater and Assess treatment technologies for wastewater
5. Select treatment methodologies for hazardous and E-waste

CO-PO-PSO Matrix

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

UNIT- I: Introduction
Definition and types of pollution. Effects of pollution on environment and ecosystems - global warming - greenhouse effect. Laws and standards for pollution. Sources, types, characteristics and effects of air pollutants, liquid effluents, solid wastes industries.

UNIT- II: Air Pollution
Meteorological aspects of pollution dispersion, Temperature lapse rates, Turbulence and stability of atmosphere. Indoor air pollution - smoke and hydrocarbons. Richardson Number, Plume raise, plume behavior and characteristics, effective stack height.

UNIT III: **Air Pollution General Control Methods and Equipment:**
Removal of sulphur dioxide, oxides of nitrogen and carbon, organic vapors from gaseous effluents. Removal of particulate matter - principle and working of settling chambers cyclone separators solid traps, fabric and fiber filters, electro-static precipitators.

UNIT IV: Introduction to water pollution –Origin of wastewater, types of water pollutants and their effects., Determination of organic matter, Determination of inorganic substances, Physical characteristics, Bacteriological measurement, Zero liquid discharge, wastewater treatment methods – RO, UF, Grey water recycling.

UNIT –V: Solid and Hazardous Waste

Solid waste management: Sources and classification, Public health aspects, Methods of collection, Disposal Methods,. Hazardous waste management: Definition and sources, Hazardous waste classification, Treatment methods, Disposal methods. E-waste: Sources, environmental and social issues, management practices.

Text Books

1. C.S.Rao, "Environmental Pollution Control Engineering", 3rd Ed, New Age International, 2018.
2. S.C. Bhatia, " Solid And Hazardous Waste Management ", Atlantic Publishers, 2021

Suggested Reading:

1. Metcalf and Eddy, "Wastewater Engineering: Treatment and Reuse", 4th Ed, MGH publishing, 2004.
2. M.N Rao and H.V.N Rao, "Air Pollution", Tata McGraw- Hill Publishing Company Limited, New Delhi, 2000.
3. Lakshmi Raghupathy, "Introduction to E-Waste Management" TERI Press,
4. Peavy, H.S., Rowe, D.R. and Technobanolous, G., "Environmental Engineering", McGraw Hill, 1985.

20CH O03 **WATER CONSERVATION AND MANAGEMENT**
(OPEN ELECTIVE)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives: This course helps the students to understand:

1. Water sources, usage and need to protect them.
2. Water quality and standards
3. Water audits and laws.
4. Watershed management system.
5. Water conservation practices.

Course outcomes: At the completion of this course, students will be able to

1. Identify natural water sources.
2. Categorize the water quality characteristics and standards.
3. Understand the water audits and laws.
4. Associate with the objectives of water management practices.
5. Use water conservation methods for agriculture and workplace.

CO-PO-PSO Matrix

CO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO1	PO1	PO1	PSO	PSO
CO	-	-	-	-	-	3	3	2	1	1	1	1	-	1
CO	-	-	-	-	-	3	3	2	1	1	1	1	-	1
CO	-	-	-	-	-	3	3	2	1	1	1	1	-	1
CO	-	-	-	-	-	3	3	2	1	1	1	1	-	1
CO	-	-	-	-	-	3	3	2	1	1	1	1	-	1

UNIT – I Introduction:
Importance of water, Natural sources of water available on earth's crust, Hydrologic cycle and water distribution -evaporation, precipitation, infiltration, runoff and subsurface flow. Composition of water in sources like sea, rain, snow, river, lake. Need to protect water supplies.

UNIT – II Water quality and standards:
Water quality classification system in India, water quality characteristics - Physical, chemical and biological, Health effects of contaminated water, Water quality parameters, Standards of drinking water prescribed by different agencies. Water Quality Index and objectives.

UNIT – III Water audits:
Raw water - Permissible limits of constituents and uses, Water rights and regulations and doctrines, water laws, water policy objectives, Water related programs in India and National water mission. Water quality related issues in India, major factors for water quality degradation.

UNIT – IV Water management:
Activities in India to improve water quality, principles of water management and key issues. Integrated water resource management. Watershed management - Necessity, objectives of approaches and practices, types of water harvesting, afforestation, rainwater harvesting, benefits, identifying locations. Water recycling – benefits, reuse drives.

UNIT – V Water conservation:

Types of water storage systems in practice. Water use, impacts and benefits. Water conservation methods, minimising evaporation. Role of NGOs in water conservation in India, Water conservation practices as case studies in agriculture and work place.

Text Books:

1. Elements of Water Pollution Control Engineering, OP Gupta, Khanna Publishing House, Delhi, 2019.
2. Glenn O. Schwab and R K Frevert, Water Conservation and Management Soil and Water Conservation Engineering, 3rd Ed., John Wiley & Sons, 1981

Suggested reading:

1. Water Supply and Sanitary Engineering, Rangwala, Charotar Publications, 2006.

20CH O04 **ENVIRONMENTAL AND SUSTAINABLE DEVELOPMENT**
(Open Elective)

Instruction	3Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives: This course will help the students:

1. To have an increased awareness on issues in areas of sustainability
2. To understand the role of engineering & technology within sustainable development
3. To know the methods, tools and incentives for sustainable product service system development
4. To establish a clear understanding of the role and impact of various aspects of engineering decisions on environmental, societal and economic problems.
5. To communicate results related to their research on sustainable engineering

Course Outcomes: At the completion of this course students will be able:

1. To relate sustainability concepts and ethical principles towards environment
2. To understand the different types of environmental pollution problems and their respect sustainable solutions.
3. To become aware of concepts, analytical methods/models, and resources for evaluating and comparing sustainability implications of engineering activities
4. To critically evaluate existing and new methods
5. To develop sustainable engineering solutions by applying methods and tools to research a specific system design
6. To apply concepts of sustainable development to address sustainability challenges in a global context.

CO-PO-PSO Matrix

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

UNIT- I

Introduction of sustainability- Need and concept of Sustainable Engineering, Social-environmental and economic sustainability concepts, Sustainable development and challenges, Multilateral Environmental acts and protocols-Clean Development Mechanism (CDM), Environmental legislations in India- Air Act and Water Act.

UNIT- II

Economic and social factors affecting sustainability, Effects of pollution from natural sources, Solid waste-sources, impacts, 4R (Reduce, Reuse, Recycling, Recover) concept, Global environmental issues-Resource degradation, Climate change, Global warming, Ozone layer depletion, Tools used to ensure sustainability in engineering activities such as environmental management systems and environmental impact assessment studies.

UNIT- III

Global, Regional and Local environmental issues, Carbon credits and Carbon trading, Carbon foot print, Environmental management standards, ISO 14000 series, Life cycle Analysis (LCA)-scope and goal, Procedures of EIA (Environment Impact Assessment) in India-Procedures of EIA in India.

UNIT- IV

Basic concept of sustainable habitat-Sustainable cities, Sustainable transport, Sustainable sources of energy-conventional and renewable sources, Green Engineering: Green buildings, Green materials for sustainable design, Green building certification, Methods for increasing energy efficiencies of buildings.

UNIT- V

Technology and sustainable development, Sustainable urbanization, Industrialization and poverty reduction, Social and Technological change, Industrial processes-material selection, Pollution prevention, Industrial ecology, Industrial symbiosis.

Text Books

1. Allen D. T and ShonnardD. R., Sustainability Engineering Concepts, Design and Case Studies, 1st Ed, Prentice Hall, 2011.
2. Bradley A. S, Adebayo A. O and Maria. P., Engineering Applications in Sustainable Design and Development, 1st Ed, Cengage Learning, 2016.

Suggested Reading:

1. Rag R. L., Introduction To Sustainable Engineering, 2nd Ed, PHI Learning Pvt Ltd, 2016.
2. Krishna R. Reddy, Claudio Cameselle, Jeffrey A. Adams., Sustainable Engineering,1st Ed, Wiley, 2019.

20CHO05 **SAFETY HAZARDS AND MANAGEMENT**
(Open Elective)

Instruction	3Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives: This course will help the students to understand the

1. Importance of safety culture in process industry.
2. Disregard for ethical decision making based on numerous case studies.
3. Interaction and implementation of trade-offs concept in chemical plant operation.
4. Examples of problems that can occur with inadequate process design, improper process modification.
5. Different case studies related to industrial processes

Course outcomes: At the completion of this course, students will be able to

1. Evaluate effect of chemical hazards and risks of toxicants.
2. Analyze chemical incidents and possible consequences to plant facilities, workers, and the general public.
3. Analyze fire and explosion hazards.
4. Integrate safety concepts into chemical plant design.
5. Apply ethics during process plant operation
6. Understand the overall safety aspects and safety audit norms for chemical process plant

CO-PO-PSO Matrix

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

Unit-I: Introduction:
Safety program, engineering ethics, concept of loss prevention, accident and loss statistics, acceptable risks, nature of accident process, inherent safety. Case studies of major disasters: Chernobyl disaster, Bhopal disaster, recent oil spills.

UNIT – III: Toxicology and Industrial Hygiene:
Toxic materials and their properties, toxicants entry route, dose versus response, models for dose and response curves, threshold limit values, Effects of toxic Agents, Industrial hygiene anticipation and identification, industrial hygiene evaluation, hygiene control.

UNIT – II: Hazard identification and Risk Assessment:
Process hazards checklists, hazard survey, hazards and operability studies (HAZOP), safety reviews, other methods, review of probability theory, event tree, and fault tree, QRA, OSHA and LOPA, Risk assessment procedures.

UNIT – IV: **Fires and explosions:**
Definition of fire, fire triangle, Classification of fires as Class-A, B, C and D, causes of fire and preventive fire and explosion hazards, methods types of explosions, explosion index, explosion-proof equipment and instruments, Fire extinguishers: Portable fire extinguishers applications and their uses..

UNIT – V: Emergency preparation and accident investigation:
On-site and off-site emergency plan and infrastructure, learning from accidents, layered investigation, equipment aiding in diagnosis. Safety audit: Introduction, essentials, requirements, programs and procedures.

Text Books

1. D. A. Crowl and J.F. Louvar, "Chemical Process Safety", Prentice Hall, New Delhi, 2011.
2. Howard H. Fawcett and W. S. Wood, "Safety & Accident prevention in chemical operations", 2nd Ed., John Wiley and Sons Inc, 1982.

Suggested Reading:

1. Coulson and Richadson, "Chemical Engineering Design", 3rd ed., Vol 6, TMH, 1999.
2. Fulekar M.H, "Industrial Hygiene and Chemical Safety", I.K. International Publisher, 2006.
3. Sanders R.E., "Chemical Process Safety: Learning from case Histories", Butterworth-Heinemann (Elsevier) pub, 2005.

20CH O06

FUEL CELL TECHNOLOGY
(Open Elective)

Instruction	3L Periods per week
Duration of SEE	3 Hours
SIE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives: This course helps the students to:

1. Create awareness about alternate clean fuel available.
2. Evaluate the concepts and chemistry of fuel cell
3. Examine the details of fuel used in fuel cell technology
4. Explain the application of fuel cell in different sectors
5. Evaluate the fuel cell system balance plant and future opportunities

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

1. Apply know-how of thermodynamics, electro-chemistry and principle of fuel cell
2. Understand the different types of fuel cell
3. Understand the components of hydrogen-based fuel cell
4. Evaluate the performance of fuel cells.
5. Explain the application of fuel cell in transport, stationary and portable sector
6. Understand the impact of this technology in a global and societal context

CO-PO-PSO Matrix

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

UNIT - I

Introduction: Electrochemical Systems and Fuel Cell, Fuel Cell Fundamentals and Basic Concepts, Fuel Cell Degradation, Fuel Cell Operation, Types Of Fuel Cell And Its Applications: Direct Carbon Fuel Cell, Solid Oxide Fuel Cell, Polymer Electrolyte Fuel Cell, Alkaline Fuel Cell, Phosphoric Acid Fuel Cell, Molten Carbonate Fuel Cell, Fuel Cell Thermodynamics - Heat, Work Potentials, Prediction of Reversible Voltage, Fuel Cell Efficiency

UNIT – II:

Fuels and Fuel Processing: Introduction, Feedstock for H_2 production: Natural gas, Liquefied petroleum gas, Liquid hydrocarbon Fuels: Gasoline and Diesel, Alcohols- Methanol and Ethanol, Ammonia, Biomass, Fuel processing for fuel cell applications: Desulfurization, fuel reforming, water gas shift reaction, Carbon monoxide Removal

UNIT – III:

Fundamental and Components of Portable Hydrogen Fuel Cell: Introduction, PEM Fuel cell Components and their properties: Membrane, Electrode, Gas diffusion layer, Bipolar plates, Stack design principles, system design, performance analysis, current/voltage, voltage efficiency and power density, ohmic resistance, direct methanol and other non-hydrogen fuel cells, biofuel cell

UNIT – IV:

Application of Fuel Cell: Hydrogen fuel cell use in transport, stationary Fuel cell characterization: - in-situ and ex-situ characterization techniques, i-V curve, frequency response analyses; Fuel cell modelling and system integration: - 1D model - Analytical solution and CFD models.

UNIT – V:

Balance of plant and commercialization issues, Future Opportunities, obstacles and challenges associated in fuel cell systems, impact of this technology in a global and societal context

Text Books

1. Nigel M. Sammes ,Fuel Cell Technology, Reaching Towards Commercialization, Springer London, 2006
2. David A Berry, Dushyant Shekhawat, J.J. Spivey, Fuel Cells: Technologies for Fuel Processing, , Elsevier Science, 2011

Suggested Readings

1. Shigenori Mitsushima, Viktor Hacker Fuel Cells and Hydrogen, From Fundamentals to Applied Research, Elsevier Science, 2018,