Department of Mechanical Engineering

Birla Institute of Technology, Mesra, Ranchi - 835215 (India)

Institute Vision

To become a Globally Recognized Academic Institution in consonance with the social, economic and ecological environment, striving continuously for excellence in education, research and technological service to the National needs.

Institute Mission

To educate students at Undergraduate, Post Graduate, Doctoral, and Post Doctoral levels to perform challenging engineering and managerial jobs in industry.

- To provide excellent research and development facilities to take up Ph.D. programmes and research projects.
- To develop effective teaching and learning skills and state of art research potential of the faculty.
- To build national capabilities in technology, education and research in emerging areas.
- To provide excellent technological services to satisfy the requirements of the industry and overall academic needs of society.

Department Vision

To become an internationally recognized Centre of excellence in academics, research and technological services in the area of Mechanical Engineering and related inter-disciplinary fields.

Department Mission

- Imparting strong fundamental concepts to students and motivate them to find innovative solutions to engineering problems independently
- Developing engineers with managerial attributes capable of applying latest technology with responsibility
- Creation of congenial atmosphere and excellent research facilities for undertaking quality research by faculty and students
- To strive for more internationally recognized publication of research papers, books and to obtain patent and copyrights
- To provide excellent technological services to industry.

Programme Educational Objectives (PEOs) – Energy Technology

PEO 1: To develop capability to understand the fundamentals of Science and Energy Technology for analyzing the engineering problems with futuristic approach.

PEO 2: To foster a confident and competent post graduate capable to solve real life practical engineering problems fulfilling the obligation towards society.

PEO 3: To inculcate an attitude for identifying and undertaking developmental work both in industry as well as in academic environment with emphasis on continuous learning enabling to excel in competitive participations at global level.

PEO 4: To nurture and nourish effective communication and interpersonal skill to work in a team with a sense of ethics and moral responsibility for achieving goal.

PROGRAM OUTCOMES (POs)
M. Tech. in Mechanical Engineering (ENERGY TECHNOLOGY)

PO1: An ability to independently carry out research/investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4: Apply software skills in the field of modeling, analysis and system simulation such as MATLAB, ANSY- CFX, Fluent for performance evaluation and optimization of nonrenewable/ renewable energy systems like bio, wind, solar and hybrid systems.

PO5: Recognize the need for lifelong learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

COURSE INFORMATION SHEET

Course code: ME541
Course title: Renewable Sources of Energy
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Create awareness about sources of energy and able to estimate how long the available conventional fuel reserves will last.
2.	Learn the fundamental concepts about solar energy systems and devices.
3.	Design wind turbine blades and know about applications of wind energy for water pumping and electricity generation.
4.	Understand the working of OTEC system and different possible ways of extracting energy from ocean, know about Biomass energy, mini-micro hydro systems and geothermal energy system.

Course Outcomes

After the end of the course, a student should be able to:

CO1.	Understand of renewable and non-renewable sources of energy
CO2.	Gain knowledge about working principle of various solar energy systems
CO3.	Understand the application of wind energy and wind energy conversion system.
CO4.	Develop capability to do basic design of bio gas plant.
CO5.	Understand the applications of different renewable energy sources like ocean thermal, hydro, geothermal energy etc.

SYLLABUS

Module 1: INTRODUCTION TO ENERGY STUDIES

Introduction, Energy science and Technology, Forms of Energy, Importance of Energy Consumption as Measure of Prosperity, Per Capita Energy Consumption, Roles and responsibility of Ministry of New and Renewable Energy Sources, Needs of renewable energy, Classification of Energy Resources, Conventional Energy Resources , Non-Conventional Energy Resources, World Energy Scenario, Indian Energy Scenario. (8L)

Module 2: SOLAR ENERGY

Introduction, Solar Radiation, Sun path diagram, Basic Sun-Earth Angles, Solar Radiation Geometry and its relation, Measurement of Solar Radiation on horizontal and tilted surfaces, Principle of Conversion of Solar Radiation into Heat, Collectors, Collector efficiency, Selective surfaces, Solar Water Heating system , Solar Cookers , Solar driers, Solar Still, Solar Furnaces, Solar Greenhouse. Solar Photovoltaic, Solar Cell fundamentals, Characteristics, Classification, Construction of module, panel and array. Solar PV Systems (stand-alone and grid connected), Solar PV Applications. Government schemes and policies. (8L)

Module 3: WIND ENERGY

Introduction, History of Wind Energy, Wind Energy Scenario of World and India. Basic principles of Wind Energy Conversion Systems (WECS), Types and Classification of WECS, Parts of WECS, Power, torque and speed characteristics, Electrical Power Output and Capacity Factor of WECS, Stand alone, grid connected and hybrid applications of WECS, Economics of wind energy utilization, Site selection criteria, Wind farm, Wind rose diagram. (8L)

Module 4: BIOMASS ENERGY

Introduction, Biomass energy, Photosynthesis process, Biomass fuels, Biomass energy conversion technologies and applications, Urban waste to Energy Conversion, Biomass Gasification, Types and application of gasifier, Biomass to Ethanol Production, Biogas production from waste biomass, Types of biogas plants, Factors affecting biogas generation, Energy plantation, Environmental impacts and benefits, Future role of biomass , Biomass programs in India. (8L)

Module 5: HYDRO POWER AND OTHER RENEWABLE ENERGY SOURCES

Hydropower: Introduction, Capacity and Potential, Small hydro, Environmental and social impacts. Tidal Energy: Introduction, Capacity and Potential, Principle of Tidal Power, Components of Tidal Power Plant, Classification of Tidal Power Plants. Ocean Thermal Energy: Introduction, Ocean Thermal Energy Conversion (OTEC), Principle of OTEC system, Methods of OTEC power generation. Geothermal Energy: Introduction, Capacity and Potential, Resources of geothermal energy. (8L)

Text Books

1. Sukhatme. S.P., Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
2. B. H. Khan, Non-Conventional Energy Resources, , The McGraw Hill
3. Twidell, J.W. & Weir, A. Renewable Energy Sources, EFN Spon Ltd., UK, 2006.
4. S. P. Sukhatme and J.K. Nayak, Solar Energy – Principles of Thermal Collection and Storage, Tata McGraw-Hill, New Delhi.
5. Garg, Prakash, Solar Energy, Fundamentals and Applications, Tata McGraw Hill.

Reference Books

1. G.D. Rai, Non-Conventional Energy Sources, Khanna Publications, New Delhi, 2011.
2. Godfrey Boyle, "Renewable Energy, Power for a Sustainable Future", Oxford University Press, U.K., 1996.
3. Khandelwal, K.C., Mahdi, S.S., Biogas Technology – A Practical Handbook, Tata McGraw-Hill, 1986.
4. Tiwari. G.N., Solar Energy – "Fundamentals Design, Modeling & Applications", Narosa Publishing House, New Delhi, 2002.
5. Freris. L.L., "Wind Energy Conversion Systems", Prentice Hall, UK, 1990.
6. Frank Krieth& John F Kreider ,Principles of Solar Energy, John Wiley, New York

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
High temperature solar thermal application
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Advance bio fuels
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	3	-	2
CO2	1	2	3	-	2
CO3	1	2	3	-	2
CO4	2	2	3	-	2
CO5	1	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME542
Course title: Fuel Technology
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Present a comprehensive and rigorous study of fuel while retaining an engineering perspective.
2.	Lay the groundwork for subsequent studies in such fields as coal, petroleum and to prepare the students to effectively use fuel in the practice of engineering.
3.	Develop an intuitive understanding of fuel technology by emphasizing the physics and physical arguments.

Course Outcomes

At the end of the course, a student should be able to:

CO1.	Classify various type of fuel.
CO2.	Analyze coal from technical prospective.
CO3.	Examine the liquid fuel extraction methods.
CO4.	Explain the production methodology of gaseous fuels
CO5.	Analyse various nuclear fuels.

SYLLABUS

Module 1: INTRODUCTION TO FUEL

Different fuel energy resources, it's Indian and global perspective, Classification of Solid, liquid and gaseous fuels, Combustion appliances for solid, liquid and gaseous fuels (8L)

Module 2: ORIGIN AND FORMATION OF COAL

Different theories on coal formation, Coal as a source of energy and chemicals in India, Coal preparation, Carbonization, Gasification and liquefaction of coal and lignite, Fundamentals of coal combustion, combustion stoichiometry, Flue gas composition, Fundamentals of coal gasification, producer gas, water gas. (8L)

Module 3: EXTRACTION OF LIQUID FUELS

Petroleum and its derived products, Petroleum refining processes, Interconversion of fuels, Liquid fuel resources, world and Indian statistics, methods for characterization of crude oil and its products, refinery operations, testing of liquid fuels, industrial process design, utilization of petroleum products, synthetic liquid fuels. (8L)

Module 4: PRODUCTION OF GASEOUS FUELS

Natural gases and its derivatives, sources, potential, Gas hydrates Different types of gaseous fuels and its resources and their characteristics, principles of manufacturing of gaseous fuels from coal and oil, kinetics and mechanism of gasification, production of industrial fuel gases, rich gases such as SNG, purification, storage and transportation of gaseous fuels. (8L)

Module 5: NUCLEAR FUELS

Oxide fuel, Metal fuel, Ceramic fuel, liquid fuel, Refused-derived fuel, Bio-fuels: Biomass, Algae, biodiesel, Alcohol Fuels: Methanol, Ethanol, Butanol, Propane, etc. (8L)

Text Books

1. J.G. Speight and B. Ozum, Petroleum Refining Process, CRC Press, 2009.
2. J. G. Speight, The Chemistry and Technology of Coal, CRC Press, 2013.

Reference Books

1. F. Peter, Fuels and Fuel Technology, Wheaten & Co. Ltd., 1st edition, 1965.
2. S. Sarkar, Fuels and Combustion, Orient Longman, 2nd edition, 1990.
3. J. G. Speight, The chemistry & Technology of Petroleum, 4th edition, CRC Press, 2006.

4. Ke Liu, C. Song and V. Subramani, Hydrogen and Syngas Production and Purification Technologies, John Wiley & Sons, 2010

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Clean Coal technology
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Advance nuclear fuels
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	3	-	2
CO2	1	2	3	-	2
CO3	1	2	3	-	2
CO4	1	2	3	-	2
CO5	1	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME543
Course title: Energy Conversion System
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P:0
Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Critically examine the technology of energy systems that will be acceptable in a world faced with global warming, local pollution, and declining supplies of oil.
2.	Focus on renewable energy sources and other non-carbon/reduced-carbon emitting sources.
3.	Analyse both the devices and the overall systems are analyzed.

Course Outcomes

At the end of the course, a student should be able to:

CO1.	Analyze the solar thermal conversion system.
CO2.	Evaluate the solar thermal conversion systems for high temperature applications.
CO3.	Analyze the Photovoltaic & Bio-Energy Conversion Systems
CO4.	Design the Fuel cells.
CO5.	Examine various Electric Energy Conversion Systems.

SYLLABUS

Module 1: SOLAR THERMAL CONVERSION SYSTEM

Relevance of solar thermal power generation; Components of solar thermal power plant, Design and performance, characteristics of different solar concentrator types suitable for thermal power generation. (8L)

Module 2: SOLAR THERMAL CONVERSION SYSTEM FOR HIGH TEMPERATURE APPLICATIONS

Types of solar thermal conversion system used in high temperature application, Tracking of solar concentrators; performance characterization of solar concentrators both line focus and point focus, Comparative analysis of the both mode focus system, Optical design and concentration characteristics of line and point focus based system. (8L)

Module 3: THERMAL ENERGY CONVERSION & BIO-ENERGY CONVERSION SYSTEMS:

Thermo-electric generator, Concepts and design considerations of MHD generators, Cycle analysis of MHD systems, Thermionic power conversion and plasma diodes, Thermo chemical Conversion. Bio-energy conversion, bio methanation technology, Thermo chemical conversions. . (8L)

Module 4: FUEL CELL TECHNOLOGY

Overview of fuel cells, Fuel cell thermodynamics, fuel cell efficiency, Fuel cell characterization, Fuel cell modelling and system integration, Balance of plant, Hydrogen production from renewable sources and storage, life cycle analysis of fuel cells. (8L)

Module 5: ELECTRIC ENERGY CONVERSION SYSTEM

Generation of electricity using different sources, Transmission and distribution losses, AC to DC and DC to AC conversions, Electric motors: Types, losses, efficiency, Lightning systems, Diesel generating systems. (8L)

Text Books

1. S. S. L. Chang, Energy Conversion, Prentice Hall, 1963.
2. S. W. Angrist, Direct Energy Conversion, Pearson, 1982.
3. R. J. Rosa, Magneto hydrodynamic Energy Conversion, Springer, 1987.
4. V. S. Bagotsky, Fuel Cell Problems and Solutions, John Wiley & Sons, 2009.

Reference Books

1. Kettani, M.A., Direct energy conversion, Addison-Wesley, Reading, Mass, 1970
2. Green M.A., Solar Cells, Prentice-Hall, Englewood Cliffs, 1982

3. Hand book Batteries and Fuel Cells. Linden, McGraw Hill, 1984.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Cost reduction in the fuel cell technology
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Advance energy conversion process
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	2	-	2
CO2	1	2	3	-	2
CO3	1	2	2	-	2
CO4	1	2	2	-	2
CO5	1	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME544
Course title: Wind Energy
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Understand the technologies that are used to harness the power of the wind.
2.	Develop an intuitive understanding of wind turbine design criterion and its conversion system.
3.	Discuss the positive and negative aspects of wind energy in relation to natural and human aspects of the environment.

Course Outcomes

At the end of the course, a student should be able to:

CO1.	Explain the existing wind energy potential.
CO2.	Analyze the various aerodynamic loads and its design criterion on wind turbine system.
CO3.	Describe the existing Wind Energy Conversion System.
CO4.	Analyze the control mechanism of wind turbine.
CO5.	Understand the application of wind energy with case studies and its environmental impacts.

SYLLABUS

Module 1: BASICS OF WIND ENERGY TECHNOLOGY

Wind statistics- Measurements and data Presentation, Historical developments, latest developments, state of art of wind energy technology, turbine rating, economic analysis of wind turbine, Indian scenario and worldwide developments, present status and future trends. Wind turbine aerodynamics. (8L)

Module 2: CHARACTERISTICS OF WIND ENERGY

Nature of atmospheric winds- Wind resource characteristics and assessment– Anemometry, speed frequency distribution, effect of height, wind rose, Weibull distribution, atmospheric turbulence, gust wind speed, effect of topography. effect of Reynolds's number, actuator disc, Betz coefficient, design of wind turbine blade, effect of stall and blade tip speed ratio and coefficient of torque. (8L)

Module 3: WIND ENERGY CONVERSION SYSTEM (WECS)

Rotor Selection, Annual Energy Output, HAWT, VAWT, Rotor Design Considerations- Number of Blades, Blade Profile -2/3 Blades and Teetering, Coning- Upwind/Downwind, Power Regulation, Yaw System- Tower, Synchronous and Asynchronous Generators and Loads, Integration of Wind Energy Converters to Electrical Networks, Inverters- Testing of WECS, WECS Control System - Requirements and Strategies. . (8L)

Module 4: CONTROL MECHANISMS

Pitch control, yaw control, Electrical and Mechanical aerodynamic braking, teeter mechanism. Wind turbine dynamics with DC and AC generators: induction and synchronous generators, variable speed operation, effect of wind turbulence. Case study of design of wind mill. (8L)

Module 5: WIND ENERGY APPLICATION

Wind pumps - Performance analysis, design concept and testing, Principle of WEG- Stand alone, grid connected and hybrid applications of WECS, Economics of wind energy utilization, Wind energy in India- Case studies, environmental impacts of wind farms. (8L)

Text Books

1. Steve Parker, "Wind power", Gareth Stevens Publishing, 2004.
2. Freris L.L., Wind Energy Conversion Systems, Prentice Hall 1990.
3. Spera D.A., Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering, ASME Press, NY 1994.

Reference books

1. Wind Energy Engineering *Trevor M. Letcher* ISBN: 978-0-12-809451-8
2. Paul Gipe, “Wind Energy Comes of Age”, John Wiley & Sons Inc., 2000.
3. Tony Burton, Nick Jenkins, David Sharpe, Ervin Bossanyi, “Wind Energy Handbook”, 2nd ed., John Wiley & Sons, 2011.
4. Paul A Lin, “Onshore and offshore wind energy”, Wiley, 2011.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Modelling of wind turbine
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
New materials for the wind turbine blade
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	3	-	2
CO2	1	2	3	-	2
CO3	1	2	3	-	2
CO4	1	2	3	-	2
CO5	1	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME545
Course title: Solar Passive Architecture
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Present a comprehensive and rigorous study of Solar passive architecture while retaining an engineering perspective.
2.	Lay the groundwork for subsequent studies in such fields as solar passive architecture and to prepare the students to effectively use solar passive architecture in the practice of engineering.
3.	Develop an intuitive understanding of fuel technology by emphasizing the physics and physical arguments.

Course Outcomes

At the end of the course, a student should be able to:

CO1.	Outline the need of solar passive architecture.
CO2.	Explain the passive solar heating of buildings
CO3.	Discuss the passive solar cooling of the building
CO4.	Explain the Climate And Human Thermal Comfort
CO5.	Point out the building rating systems

SYLLABUS

Module 1: INTRODUCTION

Need for passive architecture - Building form and functions – General aspects of solar passive heating and cooling of buildings – Thumb rules - Thermal comfort – Sun's motion - Building orientation and design – Heat transfer in buildings. (8L)

Module 2: PASSIVE SOLAR HEATING OF BUILDINGS

Direct gain – Indirect gain – Isolated gain - Passive heating concept - Thermal modeling of passive concepts – Thermal storage wall and roof – Sunspace – Prediction of heating loads in a building. . (8L)

Module 3: PASSIVE COOLING OF BUILDINGS

Passive cooling concept - Solarium Passive cooling - Ventilation cooling - Nocturnal radiation cooling -Evaporative cooling - Roof surface evaporative cooling (RSEC) - Direct evaporative cooling using drip-type (desert) coolers – Radiation cooling - Earth coupling - Basic principles and systems. . . (8L)

Module 4.: CLIMATE AND HUMAN THERMAL COMFORT

Factors affecting climate - Climatic zones and their characteristics - Urban climate - Microclimate - Implications of climate on building design - Principles of energy conscious design - Building materials - Embodied energy of building materials - Alternative building materials (8L)

Module 5: BUILDING RATING SYSTEMS

Zero energy building concept and rating systems - Energy conservation building codes – Energy management of buildings – Green globe assessment Standards –BREEAM – CASBEE – Green star–Review of CDM Techniques - GRIHA and others (8L)

Text Books

1. Jan F. Kreider, The solar heating design process: active and passive systems, McGraw-Hill, 2007.
2. David A. Bainbridge, Ken Haggard, Kenneth L. Haggard, Passive Solar Architecture: Heating, Cooling, Ventilation, Daylighting, and More Using Natural Flows, Chelsea Green Publishing, 2011.
3. N.K. Bansal, G. Hauser, G. Minke. Passive Building Design: A Handbook of Natural Climatic Control. . Elsevier Science. 1994.

Reference Books

1. HP Garg and J Prakash: Solar Energy: Fundamentals and Applications, Tata McGraw Hill, 2010.
2. Tom P. Hough, Trends in Solar Energy Research, Nova Publishers, 2006.
3. Source Wikipedia, Books LIc, Solar Architecture: Passive Solar Building Design,

Active Solar, Daylighting, Passive House, Cool Roof, Earthship, Solar Air Conditioning, General Books LLC, 2010.
4. JA Duffie and WA Beckman: Solar Engineering of Thermal Processes, Third Edition, John Wiley & Sons, 2006.
5. S Sukhatme and J Nayak: Solar Energy: Principles of Thermal Collection and Storage, Third Edition, Tata McGraw Hill, 2008.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Low cost solar passive heating and cooling
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Modelling of Solar passive architecture
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –
1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	3	-	2
CO2	1	2	3	-	2
CO3	1	2	3	-	2
CO4	1	2	3	-	2
CO5	1	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME546
Course title: Hydrogen Energy System
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 3 L: 3 T:0 P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Provide comprehensive and logical knowledge of hydrogen production, storage and utilization.
2.	Develop skills in critical thinking and reasoning about issues associated with hydrogen fuel.
3.	Understand hydrogen generation techniques and hydrogen economy.
4.	Emphasize on the hydrogen energy safety techniques.

Course Outcomes

At the end of the course, a student should be able to:

CO1.	Demonstrate the basic concepts of Hydrogen Energy.
CO2.	Illustrate the various hydrogen storage & transportation techniques.
CO3.	Examine the usage of Hydrogen Energy in various day to day applications.
CO4.	Usage of Hydrogen Energy in Advanced Applications.
CO5.	Analyze the safety issues related to use of hydrogen as fuel.

SYLLABUS

Module 1: HYDROGEN PROPERTIES AND PRODUCTION PROCESSES

Physical and Chemical properties of hydrogen. Production from fossil fuels, Steam, water. Advanced production methods- production using nuclear energy and renewable, photochemical, photocatalytic, hybrid, etc. (8L)

Module 2: HYDROGEN STORAGE, HANDLING & TRANSPORTATION

Storage Technologies, Compressed hydrogen, Cryo-adsorption, Liquid hydrogen, Slush hydrogen, Underground hydrogen storage, Hydrogen tank, Automotive Onboard hydrogen storage, Hydrogen transportation methods, Challenges associated with hydrogen transport. (8L)

Module 3: HYDROGEN UTILIZATION

I.C. Engines, power plant, gas turbines, hydrogen burners, domestic and marine applications, durability studies, field trials and effect on environment, Current use scenario, eco-friendly nature. . . (8L)

Module 4: ADVANCED TECHNOLOGIES

Fuel cells, Hydrogen Vehicles, Hydrogen Powered Cars, Hydrogen Powered planes, Hydrogen powered rockets. (8L)

Module 5: HYDROGEN SAFETY

History of accident, Safety barrier diagram, Hydrogen safety codes and standards, Hydrogen sensing, risk analysis, safety in handling, safety management. Hazard spotting and evaluation. . (8L)

Text Books

1. M. Ball and M. Wietschel, The Hydrogen Economy Opportunities and Challenges, Cambridge University Press, 2009
2. Ram B. Gupta, Hydrogen Fuel: Production, Transport, and Storage, CRC Press-Taylor & Francis, 2008
3. Peschka, Walter, Liquid hydrogen: fuel of the future, Springer-Verlag Wien, 1992.
4. Kenneth D., Jr.; Edeskuty, F. J. Williamson, Recent Developments in Hydrogen Technology, CRC Press, 1986.

Reference Books

1. M.K.G. Babu, K.A. Subramanian, Alternative Transportation Fuels: Utilization in Combustion Engines, CRC Press, 2013
2. Kazunari Sasaki et al. Hydrogen Energy Engineering: A Japanese Perspective-Springer, 2016

3. David Anthony James Rand, Ronald Dell, Hydrogen Energy: Challenges and Prospects, RSC Publishers, 2008

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Cost effective hydrogen storage
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Modelling of the hydrogen energy storage system
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	3	-	2
CO2	1	2	3	-	2
CO3	1	2	3	-	2
CO4	1	2	3	-	2
CO5	1	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME547
Course title: Energy Laboratory I
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week: 04
Class: M.Tech.
Semester / Level: I/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Expose students to the real working environment and get acquainted with the literature available of the various research challenges in the field of Energy Technology.
2.	Promote and develop presentation skills and import a knowledgeable society.
3.	Set the stage for future recruitment by potential employers.

Course Outcomes

At the end of this course, a student should be able to:

CO1.	Locate the I-V and P-V characteristic with variation in temperature and radiation under series and parallel combination.
CO2.	Predicting the effect of shading and using of bypass and blocking diode.
CO3.	Calculate the work out and power flow in the standalone PV system with various combinations.
CO4.	Deducing the discharge and charge characteristic of battery.
CO5.	Perform case studies of solar system establishments.

List of Experiments

Experiment 1: To demonstrate the I-V and P-V characteristics of PV module with varying radiation and temperature level.
Experiment 2: To demonstrate the I-V and P-V characteristics of series and parallel combination of PV modules.
Experiment 3: To show the effect of variation in tilt angle on PV module power.
Experiment 4: To demonstrate the effect of shading on module output power.
Experiment 5: To demonstrate the working of diode as Bypass diode and blocking diode.

Experiment 6: Workout power flow calculations of stand-alone PV system of DC load with battery.
Experiment 7: Workout power flow calculations of stand-alone PV system of AC load with battery.
Experiment 8: Workout power flow calculations of stand-alone PV system of DC and AC load with battery.
Experiment 9: To draw the charging and discharging characteristics of battery.
Experiment 10: Comparative performance study solar plan at BIT Mesra.

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day to day performance & Lab files	30
Quiz (es)	10
Viva	20

Semester End Examination	% Distribution
Examination Experiment Performance	30
Quiz	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	-	2
CO2	3	3	3	-	2
CO3	3	3	3	-	2
CO4	3	3	3	-	2
CO5	3	3	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD3,CD6
CO2	CD1,CD3, CD6
CO3	CD1, CD3,CD6
CO4	CD1,CD3,CD6
CO5	CD1,CD3,CD6

COURSE INFORMATION SHEET

Course code: ME548
Course title: Computational Lab
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week: 04
Class: M.Tech.
Semester / Level: I/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Provide exposure to modern computational techniques in fluid dynamics and heat transfer.
2.	Apply computational methods for solving complex engineering problems.
3.	Set the stage for future recruitment by potential employers in the field of simulation.

Course Outcomes

At the end of the course, a student should be able to:

CO1.	Recognize the importance of CFD in Heat and Fluid flow.
CO2.	Analyse forced convection heat transfer coefficient over regular bodies like cylinder.
CO3.	Solve computational problems related to fluid flows and heat transfer.
CO4.	Recognize how to handle different boundary conditions.
CO5.	Analyse how to apply different prebuilt Models in CFD.

List of Experiments

Experiment 1: To simulate a Simple Conduction Problem.
Experiment 2: To simulate a Mixed Boundary Problem (Conduction/ Convection/ Insulated).
Experiment 3: To simulate a Transient Thermal Conduction Problem.
Experiment 4: To do a Coupled Structural/Thermal Analysis.
Experiment 5: To simulate a Conjugate Heat Transfer Problem.
Experiment 6: To prepare a Computational Thermal Model of fluid flow in an elbow.
Experiment 7: To simulate fluid flow across a staggered uniformly-spaced tube arrangement.
Experiment 8: Understanding the simulation using Surface-to-Surface (S2S) Radiation Model.

Experiment 9: Simulation using the Discrete Ordinates Radiation Model.
Experiment 10: To simulate flow around an airfoil.

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day to day performance & Lab files	30
Quiz (es)	10
Viva	20

Semester End Examination	% Distribution
Examination Experiment Performance	30
Quiz	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	2
CO2	3	3	3	3	2
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	3	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD6,CD7
CO2	CD1, CD6,CD7
CO3	CD1, CD6,CD7
CO4	CD1, CD6,CD7
CO5	CD1, CD6,CD7

COURSE INFORMATION SHEET

Course code: EE597
Course title: Power Generation, Transmission and Distribution
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Expose students to the 'real' working environment in the field of power generation, transmission and distribution field.
2.	Promote and develop effective state of art in the field of power generation, transmission and distribution field.
3.	Set the stage for future recruitment by potential employers

Course Outcomes

After the end of the course, a student should be able to:

CO1.	Analyze the basic concepts of energy generation.
CO2.	Understand the Interface Auxiliaries of power system.
CO3.	Contrast high voltage A.C. transmission
CO4.	Contrast high voltage D.C. transmission
CO5.	Able to design Distribution network

SYLLABUS

Module 1: GENERATION

Synchronous generator operation, Power angle characteristics and the infinite bus concept, dynamic analysis and modeling of synchronous machines, Excitations systems, Prime mover governing systems, Automatic generation control (8L)

Module 2: INTERFACE AUXILIARIES

Power system stabilizer, Artificial intelligent controls, Power quality (8L)

Module 3: AC TRANSMISSION (HVAC)

Overhead and cables, Transmission line equations, Regulation and transmission line losses, Reactive power compensation, Flexible AC transmission (8L)

Module 4: HVDC TRANSMISSION

HVDC converters, advantages and economic considerations, converter control characteristics, analysis of HVDC link performance, Multi-terminal DC system, HVDC and FACTS (8L)

Module 5: DISTRIBUTION

Distribution systems, conductor size, Kelvin's law, performance calculations and analysis, Distribution inside and commercial buildings entrance terminology, Substation and feeder circuit design considerations, distribution automation, Futuristic power generation (8L)

Text Books

1. A.J.WoodandB.F.Wollenberg,PowerGeneration,Operation,andControl.John Wiley & Sons, 2003.
2. P.M.Anderson and AA Fouad, Power System Control and Stability, Wiley-IEEE Press, 2002

Reference Books

1. O.I.Elegrad, Electric Energy System Theory: An Introduction, T.M.H. Edition, 1982.
2. C.K.Kim, V.K.Sood, G.S.Jang, J.Lim, J.Lee, HVDC Transmission: Power Conversion Applications in Power Systems, Wiley-IEEE Press, 2009.
3. T.Gonen, Electric Power Transmission System Engineering Analysis and Design, CRC Press, 2009
4. P.Kundur , Power system stability and control, McGraw-Hill, 1994.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Programming based problems are not focused.
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Programming based numerical problems.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	-	2
CO2	2	2	3	-	2
CO3	2	2	2	-	2
CO4	2	2	3	-	2
CO5	2	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME553
Course title: Economics and Planning of Energy Systems
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Credits: 4 L: 3 T: 1 P: 0
Class schedule per week: 04
Class: M. Tech.
Semester / Level: II /05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Undertake financial feasibility evaluation studies of energy technologies and to discuss various issues involved in economics and techniques used in energy planning.
2.	Provide relevant inputs on energy-economy-environment interaction related policy studies.
3.	Should have the ability to understand the economies of different energy systems.

Course Outcomes

After the end of the course, a student should be able to:

CO1.	Outline the concept of energy and able to compare microeconomic and macroeconomic theories.
CO2.	Develop an understanding of the concepts of various interest rate methods and implement the suitable one.
CO3.	Analyze the best economic model from various available alternatives.
CO4.	Implement energy and development in energy policy and planning.
CO5.	Analyse economies of different energy system.

SYLLABUS

Module 1: INTRODUCTION

Overview of world energy scenario, Overview of India's energy scenario, Economics of various energy conservation schemes. Total energy systems, Basic economic problems. Nature of economics, Positive and normative economics, Micro and macroeconomics, Basic concepts in economics. The role of the state in economic activity, New economic policy in India, Energy economics and its relations with other branches. (8L)

Module 2: ENERGY ECONOMICS

Energy economics - Simple payback period, Discount rate, internal rate of return, Time value of money, IRR, NPV, Life cycle costing, Cost of saved energy, Cost of energy generated, Examples from energy generation and conservation. Energy chain, Primary energy analysis, Life cycle assessment, Net energy analysis. (8L)

Module 3: ECONOMICS AND PLANNING

Basics of engineering economics, Relevance of financial and economic feasibility, Evaluation of energy technologies and systems, Financial evaluation of energy technologies, Social cost benefit analysis, Methods for evaluation of tangible alternatives, Replacement analysis, Project feasibility analysis, Marketing feasibility, Technical feasibility, Financial feasibility, Risk analysis and decision trees. (8L)

Module 4: ENERGY AND DEVELOPMENT

Energy and development, Role of energy in economic development, Energy intensity and energy elasticity, National and International comparison ,Low, Middle, and High income economies , Role of International institutions – OPEC, OAPEC, IEA, and World Bank. Energy demand analysis and forecasting, Energy investment planning and project formulation, Energy pricing. Policy, planning and implications of energy. Financing of energy systems, Energy policy related acts and regulations. (8L)

Module 5: ECONOMICS OF ENERGY SYSTEM

Introduction to economics of energy system, Economics of solar energy systems, Economics of biomass energy systems, Economics of wind energy systems, Economics of ocean energy systems, Economics of geothermal energy systems, Economics of Small-Mini-Micro hydro system, Economics of hydrogen energy systems. (8L)

Text Books

1. M. Kleinpeter, Energy Planning and Policy, John Wiley & sons.
2. C.S.Park, Contemporary Engineering Economics, Prentice Hall Inc.
3. G.D. Ray, Non-Conventional Energy Sources, Khanna Publications.

4. S. P. Sukhatme and J.K. Nayak, Solar Energy – Principles of Thermal Collection and Storage, Tata McGraw-Hill, New Delhi.
5. Twidell, J.W. & Weir, A., “Renewable Energy Sources”, EFN Spon Ltd., UK.

Reference Books

1. J. Parikh, Energy Models for 2000 and Beyond, Tata McGraw Hill Publishing Company Limited.
2. M. Munasinghe and P. Meir, Energy Policy Analysis and Modeling, Cambridge University Press.
3. A.V.Desai, Energy Planning, Wiley Eastern Ltd.
4. H.Campbell and R.Broron, Benefit-Cost Analysis, Cambridge University Press.
5. Frank Krieth& John F Kreider, Principles of Solar Energy, , John Wiley, New York

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Cost effective energy system
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Effective planning of energy system
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	-	1	3	-	2
CO2	1	2	3	-	2
CO3	1	2	3	-	2
CO4	1	2	3	-	2
CO5	1	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME554
Course title: Energy Management and Auditing
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Credits: 4   L: 3   T: 1   P: 0
Class schedule per week: 04
Class: M. Tech.
Semester / Level: II /05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Present a problem oriented introductory knowledge of Energy management and energy audit.
2.	Understand basic concepts of Energy conservation.
3.	Understand Energy efficiency and cost benefit.

Course Outcomes

After the end of the course, a student should be able to:

CO1.	Outline of energy management system and related policies and Acts.
CO2.	Apply the concept of Energy Management in energy related issues
CO3.	Work with energy management system and energy audit of whole system.
CO4.	Analyse energy conservation related to environmental issues
CO5.	Carry out Auditing of energy equipments and prepare energy flow diagrams and energy audit report

SYLLABUS

Module 1: INTRODUCTION

Energy and Sources of energy, Energy consumption and GDP, Costs of exploration and utilization of resources, Energy pricing, Energy demand and supply, National energy plan, Need for Energy Policy, National and State level Energy Policies. Basic concepts of Energy Conservation and its importance, Energy Strategy for the Future, The Energy Conservation Act and its Features, Energy conservation in household, Transportation, Agricultural, Service and Industrial sectors, Lighting, HVAC Systems. (8L)

Module 2: ENERGY MANAGEMENT

History of Energy Management, Definition and Objective of Energy Management and its importance. Need of energy management, General Principles of Energy Management, Energy Management Skills, and Energy Management Strategy. Energy Management Approach. Understanding Energy Costs, Benchmarking, Energy performance, Matching energy usage to requirements, Maximizing system efficiency, Optimizing the input energy requirements, Fuel and Energy substitution. Organizing, Initiating and Managing an energy management program. Roles, responsibilities and accountability of Energy Managers. (8L)

Module 3: ENERGY AUDIT

Energy audit concepts, Definition, Need and Types of energy audit. Energy Audit Approach and Methodology. Systematic procedure for technical audit. Understanding energy audit costs, Benchmarking and Energy Performance. Energy audit based on First law and Second law of thermodynamics, Mass and Energy balances, Availability analysis, Evaluation of energy conserving opportunities, Economic analysis and life cycle costing.Duties and responsibilities of energy auditors. Energy audit instruments and their usage for auditing**.** Report-writing, preparations and presentations of energy audit reports. (8L)

Module 4: ENERGY CONSERVATION AND ENVIRONMENT

Energy conservation areas**,** Energy transmission and storage, Plant Lecture wise energy optimization Models, Data base for energy management, Energy conservation through controls, Computer aided energy management, Program organization and methodology. Energy environment interaction, Environmental issues, Global Warming, Climate Change Problem and Response, Carbon dioxide emissions, Depletion of ozone layer, Governments Regulations, Energy Economy interaction. Energy Conservation in Buildings, Energy Efficiency Ratings & ECBC (Energy Conservation Building Code) (8L)

Module 5: CASE STUDIES

Study of 4 to 6 cases of Energy Audit & Management in Industries (Boilers, Steam System, Furnaces, Insulation and Refractories, Refrigeration and Air conditioning, Cogeneration, Waste Heat recovery etc.) (8L)

Text Books

1. Amlan Chakrabarti, Energy Engineering and Management, PHI, Eastern Economy Edition.
2. Smith CB, Energy Management Principles, Pergamon Press, New York.
3. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management & Case study, Hemisphere, Washington
4. L. C. Witte, P. S. Schmidt and D. R. Brown, Industrial Energy Management and Utilization, Hemisphere Publications, Washington.

Reference Books

1. W.R.Murphy, G.Mckay, Energy Management, Butterworths.
2. C.B.Smith Energy Management Principles, Pergamon Press.
3. L.C. Witte, P.S. Schmidt, D.R. Brown , Industrial Energy Management and Utilization, Hemisphere Publication, Washington
4. Archie, W Culp , Principles of Energy Conservation, McGraw Hill
5. Munasinghe, Mohan Desai, Ashok V, Energy Demand: Analysis, Management and Conservation, Wiley Eastern Ltd., New Delhi.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Cost effective energy management
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Advance energy auditing system
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	-	1	3	-	2
CO2	1	2	3	-	2
CO3	1	2	3	-	2
CO4	-	2	3	-	2
CO5	1	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME555
Course title: Energy Storage Technology
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II /05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Present a comprehensive and rigorous study of energy storage technology while retaining an engineering perspective.
2.	Lay the groundwork for subsequent studies in such fields as thermal energy storage, electrochemical energy storage, magnetic and electric energy storage systems and to prepare the students to effectively use energy storage in the practice of engineering.
3.	Develop an intuitive understanding of energy storage technology by emphasizing the physics and physical arguments.

Course Outcomes

After the end of the course, a student should be able to:

CO1.	Outline the various type of energy storage system.
CO2.	Analyze the electrochemical energy storage systems.
CO3.	Examine the magnetic and electric energy storage systems.
CO4.	Explain the sensible heat thermal energy storage
CO5.	Estimation of latent heat thermal energy storage.

SYLLABUS

Module 1: ENERGY STORAGE

Need of energy storage, Different modes of Energy Storage. Potential energy: Pumped hydro storage; KE and Compressed gas system: Flywheel storage, compressed air energy storage; Electrical and magnetic energy storage: Capacitors, electromagnets; Chemical Energy storage: Thermo-chemical, photo-chemical, bio-chemical, electro-chemical, fossil fuels and synthetic fuels. Hydrogen for energy storage. Solar Ponds for energy storage. (8L)

Module 2: ELECTROCHEMICAL ENERGY STORAGE SYSTEMS

Batteries: Primary, Secondary, Lithium, Solid-state and molten solvent batteries; Lead acid batteries; Nickel Cadmium Batteries; Advanced Batteries. Role of carbon Nano-tubes in electrodes. (8L)

Module 3: MAGNETIC AND ELECTRIC ENERGY STORAGE SYSTEMS

Superconducting Magnet Energy Storage (SMES) systems; Capacitor and Batteries: Comparison and application; Super capacitor: Electrochemical Double Layer Capacitor (EDLC), principle of working, structure, performance and application, role of activated carbon and carbon Nano-tube. (8L)

Module 4: SENSIBLE HEAT THERMAL ENERGY STORAGE

SHS mediums; Stratified storage systems; Rock-bed storage systems; Thermal storage in buildings; Earth storage; Energy storage in aquifers; Heat storage in SHS systems; Aquifers storage. (8L)

Module 5: LATENT HEAT THERMAL ENERGY STORAGE

Phase Change Materials (PCMs); Selection criteria of PCMs; Stefan problem; Solar thermal LHTES systems; Energy conservation through LHTES systems; LHTES systems in refrigeration and air-conditioning systems; Enthalpy formulation; Numerical heat transfer in melting and freezing process. (8L)

Text Books

1. Robert, Huggins. Energy Storage: Fundamentals, Materials and Applications. Springer Press 2016.
2. Richard Baxter. Energy storage. PennWell Corp. (September 10, 2005). Elsevier

Reference Books

1. Ahmed Zobaa, Energy storage: technologies and applications. Intech Open, 2014
2. David Elliott. Energy Storage Systems. IOP Publishing, Bristol, UK 2014

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Energy Storage application for Grid application
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Advance energy storage system
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	-	2	3	-	2
CO2	1	2	3	-	2
CO3	1	2	3	-	2
CO4	-	2	3	-	2
CO5	-	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME556
Course title: Heat and Mass Transfer
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II /05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Investigate cases of heat and mass transfer process in terms of similarity parameters.
2.	Study various applications, mathematical relations of heat and mass transfer.
3.	Analyze heat and mass transfer and do thermal design at industry level.

Course Outcomes

After the end of the course, a student should be able to:

CO1.	Extend the similarity concept in velocity and thermal boundary layer for isothermal and non-isothermal cases.
CO2.	Examine the Analogy between flow field and heat transfer.
CO3.	Apply the boundary layer concept in pipe and duct flow.
CO4.	Formulate and estimate free convection heat transfer.
CO5.	Explain and estimate mass transfer.

SYLLABUS

Module 1:

Similarity concepts in heat transfer for laminar and turbulent flows; Boundary layer equations; Boundary layer integral equation; similarity and integral solutions of flow over isothermal and non-isothermal flat plate, Numerical solutions. (9L)

Module 2:

Turbulent Flows: governing equations, mixing length turbulence models, analogy solutions for heat transfer in turbulent flows, near walls region, transition from laminar to turbulent flow, analogy solution for boundary layer flows, numerical solutions., viscous dissipation effects. (7L)

Module 3:

Fully developed pipe and plane duct flow under constant heat flux and constant wall temperature; Pipe flow with developing temperature field; Fully developed laminar flow in ducts with other cross-sectional shapes. (7L)

Module 4:

Concept of free convection for plate and cylinders at constant heat flux and constant wall temperature; free convection in finned surfaces and PCBs; free convection in plane enclosures and in concentric cylindrical enclosures. (8L)

Module 5:

Significant parameters in convective mass transfer, application of dimensional analysis to Mass Transfer, Analogies among mass, heat, and momentum transfer, Convective mass transfer correlations, Mass transfer between phases, Simultaneous heat and mass transfer. (9L)

Text Books

1. Heat and Mass Transfer, Y. A. Cengel and A. J. Ghajar, McGraw-Hill Education, 2014.
2. An Introduction to convective Heat Transfer Analysis, P. H. Oosthuizen and D. Naylor, 1999.

Reference Books

1. Fundamentals of Heat and Mass Transfer, Frank P. Incropera, John Wiley & Sons, 2006.
2. Convective Heat and Mass Transfer, William M. Kays & Michael E Crawford, McGraw-Hill Science/Engineering/Math, 1993.
3. Principles of Heat Transfer, Frank Kreith and Mark S. Bohn, West Publishing Company, 1993.
4. Heat Exchange Design, D.Q. Kern, McGraw-Hill Book Co., Inc., New York, 1950.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):
Programming based problems are not focused
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Programming based numerical problems.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	-	2
CO2	3	3	3	-	2
CO3	3	3	3	-	2
CO4	3	3	2	-	2
CO5	3	3	2	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME557
Course title: Integrated Energy System
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II /05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Expose students to the 'real' working environment in the field of Integrated Energy System.
2.	Promote and develop effective state of art in the field of Integrated Energy System.
3.	Set the stage for future recruitment by potential employers.

Course Outcomes

After the end of the course, a student should be able to:

CO1.	Analyze the fuel availability pattern and its usual demand pattern.
CO2.	Project the energy demands.
CO3.	Understand the potential of renewable energy sources.
CO4.	Design Integrated energy models of various energy sources.
CO5.	Understand the need of power quality.

SYLLABUS

Module 1:

Pattern of fuel consumption: agricultural, domestic, industrial and community needs. (8L)

Module 2:

Projection of energy demands, Substitution of conventional sources by alternative sources and more efficient modern technologies. (8L)

Module 3:

Potential, availability as well as capacity of solar, wind, biogas, natural gas, forest produce, tidal, geothermal, mini-hydro and other modern applications. (8L)

Module 4:

Hybrid and integrated energy systems, Total energy concept and waste heat utilization, Energy modeling to optimize different systems. (8L)

Module 5:

Power Quality: voltage regulation, frequency matching, Synchroscope.

Application of Power electronics in the Integrated energy System: HVAC to HVDC, MPPT, converter, rectifier and inverter. (8L)

Text Books

1. Renewable Energy Sources for fuels and Electricity by Laurie Barrtom.
2. Wind-Diesel Systems by R. Hunter and G. Elliot, Cambridge University Press.

Reference Books

1. P.Kundur , Power system stability and control, McGraw-Hill, 1994.
2. Dragan Maksimovic, Robert Warren Erickson, Springer, 1997

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

<u>Gaps in the syllabus (to meet Industry/Profession requirements)</u> :
Programming based problems are not focused
POs met through Gaps in the Syllabus: **PO3**

<u>Topics beyond syllabus/Advanced topics/Design:</u>
Programming based numerical problems.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	-	2
CO2	3	3	3	-	2
CO3	3	3	3	-	2
CO4	3	3	2	-	2
CO5	3	3	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME558
Course title: Energy Laboratory II
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week: 04
Class: M.Tech.
Semester / Level: II/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Be aware of the immediate market opportunities and challenges in fuel cell systems, and the current state of the art.
2.	Gain hands-on experience of different types of Solar Thermal Energy Systems.
3.	Set the stage for future recruitment by potential employers.

Course Outcomes

At the end of the course, a student should be able to:

CO1.	Evaluate performance of fuel cells.
CO2.	Operate and maintain the existing fuel cell systems.
CO3.	Train personnel in the method and development of fuel cell technology.
CO4.	Calculate the various parameters in the inside solar water heater.
CO5.	Provide training in operation and maintenance of solar thermal energy equipment.

List of Experiments

Experiment 1: Characteristics of fuel cell with the help of resistive load or DC-DC converter
Experiment 2: Output power variation of fuel cell with change in Hydrogen supply
Experiment 3: Evaluate Fuel cell system performance with only DC load connected to the charge controller with battery bank.
Experiment 4: Evaluate Fuel cell System performance with only AC load connected to the inverter with battery bank.
Experiment 5: Evaluation of U_L, F_R and η in thermosyphonic mode of flow with fixed input parameters.
Experiment 6: Evaluation of U_L, F_R and η and drawing of different curves in forced mode of flow at different flow rate.

Experiment 7: Evaluation of U_L, F_R and η in forced mode of flow at different radiation level Maximum radiation level.
Experiment 8: Evaluation of U_L, F_R and η in thermosyphonic mode of flow with different wind speed.
Experiment 9: Evaluation of U_L, F_R and η and drawing different curves in forced mode of flow at different flow rate.
Experiment 10: Evaluation of U_L, F_R and η in forced mode of flow at different tilt angle.

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day to day performance & Lab files	30
Quiz (es)	10
Viva	20

Semester End Examination	% Distribution
Examination Experiment Performance	30
Quiz	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	-	2
CO2	3	3	3	-	2
CO3	3	3	3	-	2
CO4	3	3	3	-	2
CO5	3	3	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD3,CD6
CO2	CD1,CD3, CD6
CO3	CD1, CD3,CD6
CO4	CD1,CD3,CD6
CO5	CD1,CD3,CD6

COURSE INFORMATION SHEET

Course code: ME600
Course title: Thesis Part I
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 8 L: T: P:
Class schedule per week:
Class: M.Tech.
Semester / Level: III/06
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Solve real world problems and challenges.
2.	Solve the various research challenges in the field of Energy Technology.
3.	Create awareness among the students of the characteristics of several domain areas where their project ideas could help humanity.
4.	Improve the team building, communication and management skills of the students

Course Outcomes

At the end of the course, a student should be able to:

CO1.	Demonstrate a sound technical knowledge of their selected project topic.
CO2.	Undertake problem identification, formulation and solution.
CO3.	Design engineering solutions to complex problems utilizing a systems approach.
CO4.	Communicate with engineers and the community at large in written and oral forms.
CO5.	Demonstrate the knowledge, skills and attitudes of a professional engineer.

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	2
CO2	3		3	3	2
CO3	3		3	3	2
CO4	1	3	3	3	2
CO5	3	3	3	3	2

< 34% = 1, 34-66% = 2, > 66% = 3

COURSE INFORMATION SHEET

Course code: ME639
Course title: Energy Simulation and Modelling
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III /06
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Provide knowledge, understanding and application oriented skills on Energy, Modeling and Simulation.
2.	Study the various model in details which are useful for energy planning.
3.	Utilize the modeling techniques for simulating and helping in meeting electricity demand with minimum wastage.

Course Outcomes

After the end of the course, a student should be able to:

CO1.	Understand the various energy policies.
CO2.	Analyze the different Input-Output and Econometric Models.
CO3.	Solve problems on various Optimization Models.
CO4.	Analyze the Process Analysis Models.
CO5.	Review the System Dynamic and Other Simulation Models

SYLLABUS

Module 1: INTRODUCTION

Energy policy analysis; need for energy modeling; classification of energy models; types of computer based tools for energy planning; national and rural energy planning; sectorial energy planning. (8L)

Module 2: INPUT-OUTPUT AND ECONOMETRIC MODELS

Types and Characteristics of I-O models; use of I-O models; IO transaction tables; method of estimation and sources of data; mathematical expression on the methodology of construction of I-O tables; case studies. Statistical estimation techniques; time series; regression analysis; advantages and limitations of econometric models; elastic ties of energy demand; case studies. (8L)

Module 3: OPTIMIZATION MODELS

Linear and non-linear optimization models; advantage and limitation of optimization models; case studies of linear optimization models for national and rural energy planning (8L)

Module 4: PROCESS ANALYSIS MODELS

End-use models; process analysis models for industrial, domestic and transport energy conservation; advantage and limitations of process analysis models; case studies. (8L)

Module 5: SYSTEM DYNAMIC AND OTHER SIMULATION MODELS

Concept of closed system; causal loop diagram; flow diagram and system equations; dynamic behavior of energy systems; advantages and limitations of simulation models; case studies. (8L)

Text Books

1. J.P. Weyant & T. A. Kuczmowski "Engineering- Economy Modeling: Energy Systems" Energy-The International Issue (Special issue an energy modeling), Pergaman Press. Vol. 15, No. ¾ PP 145-715, 1990.
2. Richard de Nenfville, " Applied Systems Analysis" Mc Graw Hill International Eds. 1990.

Reference Books

1. J. W. Forrester, "Principles of Systems" MIT Press, 1982.
2. Rene Codoni, Hi- Chun Park, K.V. Ramani, " Integrated Energy Planning: A Manual" Volume on policy planning, Asian & Pacific Development Center, Kuala Lumpur 1985.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Improved Energy simulation technology
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Cost effective Energy modelling
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	-	3	2	-	2
CO2	2	2	3	-	2
CO3	2	2	2	-	2
CO4	2	2	3	-	2
CO5	2	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME622
Course title: Bioconversion & Processing of Waste
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III /06
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Give an idea about different biomass and other solid waste materials as energy source.
2.	Have comprehensive knowledge of how wastes are utilized for recovery of value.
3.	Study in detail the processing and utilization of biomass for recovery of energy and other valuable products.

Course Outcomes

After the end of the course, a student should be able to:

CO1.	Understand the basics of biomass.
CO2.	Analyze the different biological conversion methods.
CO3.	Examine the other Conversion methods.
CO4.	Evaluate the various waste processing techniques.
CO5.	Design the biogas digester.

SYLLABUS

Module 1: INTRODUCTION

Biomass and solid wastes, Broad classification, Sources of Bio mass, Production of biomass, biomass yield comparison, photosynthesis, world scenario, Environmental effects. (8L)

Module 2: BIOLOGICAL CONVERSION

Biodegradation and biodegradability of substrate - Biochemistry and process parameters of biomethanation - Biomethanation Process - Bioconversion of substrates into alcohol - Methanol & ethanol Production - Organic acids – Solvents - Amino acids - Antibiotics etc, agro chemical conversion. (8L)

Module 3: OTHER CONVERSIONS

Thermo chemical conversion of biomass, conversion to solid, liquid and gaseous fuels, pyrolysis, gasification, combustion, Enzymatic Fermentation, Gas/liquid Fermentation, Acid hydrolysis and hydrogenation. (8L)

Module 4: WASTE PROCESSING

Separation of components of solid wastes, handling and processing techniques, composting technique, recycling, Agro and forestry residues utilization through conversion routes, Use of biodegradable waste. (8L)

Module 5: DESIGN AND ECONOMICS

Economics of biogas plant with their environmental and social impacts, Biogas digester types - Digester design and biogas utilization, Fuel conversion into electricity, Climate change Impact, case studies, Conversion of municipal waste into petrol. (8L)

Text Books

1. S.Samir, R.Zaborsky, Biomass Conversion Processes for Energy and Fuels, New York, Plenum Press, 1981.
2. H.D.Joseph, P.Joseph, H.John, Solid Waste Management, New York, Van Nostrand, 1973.
3. Jianzhong Sun et al. Biological Conversion of Biomass for Fuels and Chemicals: Explorations from Natural Utilization Systems (Energy and Environment Series), RSC Publishing, 2013.

Reference Books

1. G.Tchobanoglous, H.Theisen, S.V.Tchobanoglous, G.Theisen, H.V.Samuel, Integrated Solid Waste management: Engineering Principles and Management issues, New York, McGraw Hill, 1993.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Cost effective waste utilization
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Advance methodology for waste utilization
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –
1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	-		2	-	2
CO2	2	2	3	-	2
CO3	2	2	3	-	2
CO4	-	2	2	-	2
CO5	3	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME623
Course title: Solar Photovoltaic System
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III /06
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Introduce students to the various aspects of PV technologies.
2.	Enable students to understand the working principle of Photovoltaic Solar Cells.
3.	Make students familiar about the different solar cell technologies.
4.	Emphasize about the different materials and recent advances in Solar PV technology.
5.	Develop understanding of solar PV systems in power generation.

Course Outcomes

After the end of the course, a student should be able to:

CO1.	Demonstrate the basic concepts of Photovoltaic Cells.
CO2.	Illustrate the working principles of Photovoltaic Solar Cells.
CO3.	Analyze the different Solar Cell Technologies.
CO4.	Compare the current research fields in Solar Photovoltaic.
CO5.	Design the Solar PV Systems.

SYLLABUS

Module 1: FUNDAMENTALS OF PHOTOVOLTAIC CELLS

Solar cell working, General Types, Testing of Solar cells, Materials used for manufacturing, manufacturing processes involved for fabrication, Decreasing cost of PV cells, present scenario, Solar cells, modules, panels and systems. (8L)

Module 2: PHOTOVOLTAIC CELLS WORKING

Review of semiconductor physics and Operating principle, Design of solar cells-Cell parameters limits, Losses in solar cells, Solar cell design for high Isc, Voc and FF, PV device characterization. Factors affecting the efficiency of solar cell, Strategies to enhance the efficiency of solar cell. Environmental effects of Photovoltaic. (8L)

Module 3: SOLAR CELL TECHNOLOGIES

First, Second and Third Generation PV Silicon based technologies. Manufacturing processes (wafer, cell and module) for Solar cells. Concept of multi-junction or tandem cells, concentrating technologies, Optics for concentrators, PV-Tracking Requirements, High concentrator solar cells. (8L)

Module 4: RECENT ADVANCES

Emerging solar cell technologies (Organic PV, Hetero junction with intrinsic thin film – HIT - Quantum dots - Dye Sensitized Solar cell - Perovskite solar cells etc). (8L)

Module 5: PV MODULE AND PV SYSTEM APPLICATIONS

Solar PV system, Batteries for PV systems -DC to DC and DC to AC converters-charge controllers, stand alone, hybrid and grid connected system, Standalone PV systems (Lighting, Water Pumping etc.), Design methodology of PV off grid and grid connected systems, Load estimation and System Sizing, Design of roof top solar PV power plants. (8L)

Text Books

1. Mertens K. ,2013, Photovoltaics: Fundamentals, Technology and Practice, Wiley
2. Solanki C. S. ,2009, Solar Photovoltaics: Fundamentals, Technologies and Applications, Prentice Hall India

Reference Books

1. Mukerjee A. K. and Thakur N. ,2011, Photovoltaic systems: analysis and design, PHI
2. V Barbec, V.Dyakonov, J. Parisi, N.S. Saricifttci, 2003, Organic photovoltaics: Concepts and realization, Springer Verlag
3. Tiwari G N, 2012, Solar Energy: Fundamentals, Design, Modelling and Application

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Cost effective improved solar photovoltaic system
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Improved modelling of the solar photovoltaic system
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	-	2	2	-	2
CO2	2	2	2	-	2
CO3	-	2	3	-	2
CO4	-	2	3	-	2
CO5	2	2	2	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME624
Course title: Nuclear Energy
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III /06
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Understand the sources of energy and their contributions to the energy and power needs of the nation and the world.
2.	Understand the special engineering challenges of using each of these sources of energy efficiently and environmentally effectively.
3.	Develop an intuitive understanding of the economics behind the costs of the uses and applications of each of these forms of energy.
4.	Understand the energy conversion systems for nuclear power plants, the advantages/disadvantages (including overall environmental effects) of each type of present plants.

Course Outcomes

After the end of the course, a student should be able to:

CO1.	Analyze the basic concepts of nuclear energy.
CO2.	Describe the interaction of neutrons with matter.
CO3.	Contrast between nuclear fusion and fission reactions.
CO4.	Application of reactor theory in power rector.
CO5.	Point out the plasma concepts.

SYLLABUS

Module 1: INTRODUCTION TO NUCLEAR ENERGY

Nuclear nomenclature, Binding energy and semi-empirical mass formula, Radioactive decay, fission and fusion energy, typical reactions, concepts of Binding Energy of a nuclear reaction, mass energy equivalence and conservation laws, nuclear stability and radioactive decay, radioactivity calculations, Health Hazards: radiation protection & shielding. (8L)

Module 2: INTERACTION OF NEUTRONS WITH MATTER

Compound nucleus formation, elastic and inelastic scattering, cross sections, energy loss in scattering collisions, polyenergetic neutrons, critical energy of fission, fission cross sections, fission products, fission neutrons, energy released in fission, γ-ray interaction with matter and energy deposition, fission fragments. (8L)

Module 3: NUCLEAR FUSION AND FISSION REACTIONS

Fusion reactions, reaction cross-sections, reaction rates, fusion power density, radiation losses, ideal fusion ignition, Ideal plasma confinement & Lawson criterion. The fission chain reaction, reactor fuels, conversion and breeding, the nuclear power resources, nuclear power plant & its components, power reactors and current status. (8L)

Module 4: REACTOR THEORY & PLASMA CONCEPTS

Neutron flux, Fick's law, continuity equation, diffusion equation, boundary conditions, solutions of the DE, group diffusion method, Neutron moderation (two group calculation), one group reactor equation and the slab reactor.

Saha equation, Coulomb scattering, radiation from plasma, transport phenomena, Plasma Confinement Schemes: Magnetic and inertial confinement, current status. (8L)

Module 5: NUCLEAR REACTOR

Classification of the nuclear reactor and its important Components. Pressurized water reactors (PWR), Boiling water reactors (BWR), Pressurized Heavy Water Reactor (PHWR), Reaktor Bolshoy Moschnosti Kanalniy (High Power Channel Reactor) (RBMK), Gas-cooled reactor (GCR) and advanced gas-cooled reactor (AGR), Liquid-metal fast-breeder reactor (LMFBR), Pebble-bed reactors (PBR), Molten salt reactors, Aqueous Homogeneous Reactor (AHR) (8L)

Text Books

1. Nuclear energy by Redman, L.A. 1963, Oxford university press.
2. R.A. Gross, Fusion Energy, John Wiley & Sons Inc., 2008.

Reference Books

1. R. K., Taneja. Nuclear energy, Cyber Tech Publications New Delhi, 2009.

2. F.F. Chen, Introduction to Plasma Physics & Controlled Fusion, Plenum Press, 2004.
3. Weston M. Stacey, Fusion: An Introduction to the physics and technology of magnetic Confinement Fusion, 2nd edition, Wiley- VCH Publication 1984.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Safe disposal of nuclear waste
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Advance nuclear fuels
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –
1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	-	2	3	-	2
CO2	1	2	3	-	2
CO3	1	2	3	-	2
CO4	-	2	3	-	2
CO5	-	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME625
Course title: Energy Ecology and Environment
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III /06
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Introduce the concept of energy, ecology and environment.
2.	Lay groundwork for understanding the relationship between energy, ecology and environment.
3.	Enable the student to understand the relation between energy and environment.
4.	Emphasize on the factors that leads to degradation of environment.
5.	Create awareness about the various environmental remediation techniques.

Course Outcomes

After the end of the course, a student should be able to:

CO1.	Understand the relationship between Energy, Ecology and Environment.
CO2.	Classify the various energy sources.
CO3.	Analyze the connection between Energy and Environment.
CO4.	Examine the various Environment Degrading Factors.
CO5.	Choose proper Environment Remediation Techniques.

SYLLABUS

Module 1: INTRODUCTION

Connection between energy and environment, Sun as energy source, solar radiation, Biological processes, photosynthesis, Synecology and Autecology. Effect of Population on Ecosystem, Community Ecosystem (wetland, terrestrial, marine), Food chains, Ecosystem theories, biogeochemical and water cycling, terrestrial carbon cycling, Environmental Nanotechnology. (8L)

Module 2: SOURCES OF ENERGY

Classification of energy sources, Renewable/Non-Renewable Sources, Advantages and Disadvantages of different energy sources, Utilization of different energy sources. Energy, Demand and cost Analysis. Recent advances in energy sector. (8L)

Module 3: ENERGY AND ENVIRONMENT

Environmental problems linked with harnessing of fossil fuels (coal, oil, natural gas), nuclear energy, hydropower, biomass, solar, geothermal, tidal, wind, Energy flow and nutrient cycling in ecosystems. (8L)

Module 4: ENVIRONMENTAL DEGRADATION

Primary and secondary pollutants, air, soil and water pollution, thermal pollution, radioactive pollution, effect of pollution on climate, Pollution sources, Biological effects of radiation, Acid rain, etc, methods and techniques to study effect of nanoparticles in the environment, Toxicity of the nanomaterial and its possible impacts in the environment. (8L)

Module 5: ENVIRONMENTAL REMEDIATION

Waste disposal, Toxic Waste handling, Transportation of fuels and waste, Recycling, Methods to control Nano-particle pollution, Regulations of Industry to control waste, Pollution Control boards (8L)

Text Books

1. G. M. Masters, W P Ela, Introduction to Environmental Engineering and Science, Prentice Hall, 3 rd Edition, 2007.
2. Richard Wilson, Energy, Ecology, and the Environment, Academic Press 1974.

Reference Books

1. D. Nevers, Air Pollution Control Engineering, McGraw Hill, 2001.
2. Nikhil Sharma et al., Air Pollution and Control, Energy Environment and Sustainability Springer, 2017
3. A. Mackenzie, A. S. Ball and S. Virdee, Instant Notes: Ecology, 2nd Edition, BIOS Scientific Publishers Ltd., 2001.

4. F. Armstrong and K. Blunde, Energy Beyond oil, Oxford University Press, 2007.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Clean Energy technology
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Advance environmental technology
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	-		2	-	2
CO2	-	2	2	-	2
CO3	2	2	2	-	2
CO4	-	2	3	-	2
CO5	2	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME627
Course title: Simulation Lab
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week: 04
Class: M.Tech.
Semester / Level: III/06
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Solve linear system of equations.
2.	Apply numerical integration method.
3.	Analyse nature of functions.
4.	Apply Numerical Methods for differential equations.
5.	Evaluate Characteristics of functions.

Course Outcomes

At the end of the course, a student should be able to:

CO1.	Evaluate the linear differential equations.
CO2.	Evaluate the nature of functions.
CO3.	Analyse the nature of differential equations.
CO4.	Perform comparative analysis of numerical methods.
CO5.	Perform comparative analysis of numerical integration methods.

List of Experiments

Experiment 1: To solve linear system of equations using Gaussian elimination.
Experiment 2: To solve linear system of equations using Gauss siedel.
Experiment 3: To solve linear system of equations using Gauss Jordan.
Experiment 4: Numerical Integration using Trapezoidal rule and Simpson rule.
Experiment 5: Numerical Integration using Romberg Integration.
Experiment 6: Numerical Integration using Quadrature formula.
Experiment 7: Finding maxima, minima of multivariable functions.
Experiment 8: Using least square method for approximation of functions.
Experiment 9: Applying conjugate gradient method.
Experiment 10: Solving ODE’s using numerical Methods.

Experiment 11: To use Euler's Method for solving system of differential equations.
Experiment 12: To use Runge Kutta for solving autonomous and non-autonomous system of differential equations.

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day to day performance & Lab files	30
Quiz (es)	10
Viva	20

Semester End Examination	% Distribution
Examination Experiment Performance	30
Quiz	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	2
CO2	3		3	3	2
CO3	3		3	3	2
CO4	2	3	3	3	2
CO5	3	3	3	3	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6,CD7
CO2	CD1,CD6,CD7
CO3	CD1,CD6,CD7
CO4	CD1,CD6,CD7
CO5	CD1,CD6,CD7

COURSE INFORMATION SHEET

Course code: ME650
Course title: Thesis Part II
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 16 L: T: P:
Class schedule per week:
Class: M.Tech.
Semester / Level: IV/06
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Solve real world problems and challenges.
2.	Solve the various research challenges in the field of Energy Technology.
3.	Create awareness among the students of the characteristics of several domain areas where their project ideas could help humanity.
4.	Improve the team building, communication and management skills of the students

Course Outcomes

At the end of the course, a student should be able to:

CO1.	Demonstrate a sound technical knowledge of their selected project topic.
CO2.	Undertake problem identification, formulation and solution.
CO3.	Design engineering solutions to complex problems utilizing a systems approach.
CO4.	Communicate with engineers and the community at large in written and oral forms.
CO5.	Demonstrate the knowledge, skills and attitudes of a professional engineer.

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	2
CO2	3		3	3	2
CO3	3		3	3	2
CO4	1	3	3	3	2
CO5	3	3	3	3	2

< 34% = 1, 34-66% = 2, > 66% = 3

OPEN ELECTIVES

COURSE INFORMATION SHEET

Course code: ME582
Course title: Design Methodology
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/II /05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Gain concepts of design research and methodology
2.	Carry out research into design.
3.	Understand design as a phenomenon.
4.	Identify research topics.
5.	Understand structures of research documentation.

Course Outcomes

At the end of the course, a student should be able to:

CO1.	Determine type of research to be persuaded.
CO2.	Improve design aspects in a systematic way.
CO3.	Develop a research plan.
CO4.	Validate the improvements in a methodical manner.
CO5.	Document and report research process and outcomes.

SYLLABUS

Module 1:

Introduction to design research: What and Why; Current issues with design research and the need for a design research methodology; Major facets of design and design research. Introduction to design research methodology - its main components, and examples to explain the components. (8L)

Module 2:

Starting design research: Clarification of requirements: Identifying research topics, carrying out literature search, consolidating the topic into research questions and hypotheses, and developing a research plan. (8L)

Module 3:

Descriptive study: Type, Processes for carrying out descriptive studies for developing an understanding a facet of design and its influences; Introduction to associated descriptive study real-time and retrospective research methods for data collection such as protocol analysis, questionnaire surveys, interviews etc; Introduction to quantitative and qualitative data analysis methods. (8L)

Module 4:

Prescriptive study: Types, Processes for developing design support and associated prescriptive study research methods. Types of support evaluation; Processes for evaluating a design support, and associated Evaluation study research methods. (8L)

Module 5:

Documentation: Types and structures of research documentation, Approaches and guidelines for documenting and reporting research process and outcomes. (8L)

Text Books

1. The Future of Design Methodology, Editors: Birkhofer, Herbert (Ed.) Springer-Verlag, 2011.
2. Design Thinking Methodology, Emrah Yayici.
3. Universal Methods of Design: 100 Ways to Research Complex Problems, Develop Innovative Ideas, and Design Effective Solutions, Bruce Hanington and Bella Martin 2012

Reference Books

1. Blessing, L.T.M., Chakrabarti A. and Wallace, K.M. An Overview of Design Studies in Relation to a Design Research Methodology, Designers: the Key to Successful Product Development, Frankenberger & Badke-Schaub (Eds.), Springer-Verlag, 1998.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Cost effective design methods.
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Advanced design methods.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2		2
CO2	1	3	2		2
CO3	1	3	2		1
CO4	2	3	2		1
CO5	2	3	2		3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2,CD6
CO3	CD1,CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME583
Course title: Renewable Energy
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Co- requisite(s): Nil
Credits: 3   L: 3   T: 0   P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/II /05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Create awareness about sources of energy and able to estimate how long the available conventional fuel reserves will last.
2.	Learn the fundamental concepts about solar energy systems and devices.
3.	Design wind turbine blades and know about applications of wind energy for water pumping and electricity generation.
4.	Understand the working of advanced renewable energy sources.

Course Outcomes

At the end of the course, a student should be able to:

CO1.	Understand of renewable and non-renewable sources of energy.
CO2.	Gain knowledge about working principle of various solar energy systems
CO3.	Understand the application of wind energy and wind energy conversion system.
CO4.	Develop capability to do basic design of bio gas plant.
CO5.	Understand the applications of different advanced renewable energy sources.

SYLLABUS

Module 1: INTRODUCTION TO ENERGY STUDIES

Introduction, Energy science and Technology, Forms of Energy, Importance of Energy Consumption as Measure of Prosperity, Per Capita Energy Consumption, Roles and responsibility of Ministry of New and Renewable Energy Sources, Needs of renewable energy, Classification of Energy Resources, Conventional Energy Resources , Non-Conventional Energy Resources, World Energy Scenario, Indian Energy Scenario. (8L)

Module 2: SOLAR ENERGY

Introduction, Solar Radiation, Sun path diagram, Basic Sun-Earth Angles, Solar Radiation Geometry and its relation, Measurement of Solar Radiation on horizontal and tilted surfaces, Principle of Conversion of Solar Radiation into Heat, Collectors, Collector efficiency, Selective surfaces, Solar Water Heating system , Solar Cookers , Solar driers, Solar Still, Solar Furnaces, Solar Greenhouse. Solar Photovoltaic, Solar Cell fundamentals, Characteristics, Classification, Construction of module, panel and array. Solar PV Systems (stand-alone and grid connected), Solar PV Applications. Government schemes and policies.

(8L)

Module 3: WIND ENERGY

Introduction, History of Wind Energy, Wind Energy Scenario of World and India. Basic principles of Wind Energy Conversion Systems (WECS), Types and Classification of WECS, Parts of WECS, Power, torque and speed characteristics, Electrical Power Output and Capacity Factor of WECS, Stand alone, grid connected and hybrid applications of WECS, Economics of wind energy utilization, Site selection criteria, Wind farm, Wind rose diagram.

(8L)

Module 4: BIOMASS ENERGY

Introduction, Biomass energy, Photosynthesis process, Biomass fuels, Biomass energy conversion technologies and applications, Urban waste to Energy Conversion, Biomass Gasification, Types and application of gasifier, Biomass to Ethanol Production, Biogas production from waste biomass, Types of biogas plants, Factors affecting biogas generation, Energy plantation, Environmental impacts and benefits, Future role of biomass , Biomass programs in India. (8L)

Module 5: ADVANCED RENEWABLE ENERGY SOURCES

Introduction to advanced renewable energy, Hydropower, Wave Energy, Tidal Energy, Ocean Thermal Energy, Geothermal Energy, Bio-fuels, Animal Energy. (8L)

Text Books

1. Sukhatme. S.P., Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
2. B. H. Khan, Non-Conventional Energy Resources, , The McGraw Hill
3. G N Tiwari, R K Mishra, Advanced renewable energy sources, RSC Publishing, 2012
4. Twidell, J.W. & Weir, A. Renewable Energy Sources, EFN Spon Ltd., UK, 2006.
5. S. P. Sukhatme and J.K. Nayak, Solar Energy – Principles of Thermal Collection and Storage, Tata McGraw-Hill, New Delhi.
6. Garg, Prakash, Solar Energy, Fundamentals and Applications, Tata McGraw Hill.

Reference Books

1. G.D. Rai, Non-Conventional Energy Sources, Khanna Publications, New Delhi, 2011.
2. Godfrey Boyle, "Renewable Energy, Power for a Sustainable Future", Oxford University Press, U.K., 1996.
3. Khandelwal, K.C., Mahdi, S.S., Biogas Technology – A Practical Handbook, Tata McGraw-Hill, 1986.
4. Tiwari. G.N., Solar Energy – "Fundamentals Design, Modeling & Applications", Narosa Publishing House, New Delhi, 2002.
5. Freris. L.L., "Wind Energy Conversion Systems", Prentice Hall, UK, 1990.
6. Frank Krieth& John F Kreider ,Principles of Solar Energy, John Wiley, New York

Course Evaluation:

Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

High temperature solar thermal application

POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:

Advance bio fuels

POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1	2	3	-	2
CO2	1	2	3	-	2
CO3	1	2	3	-	2
CO4	2	2	3	-	2
CO5	1	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME584
Course title: Energy Management Principles and Auditing
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/II /05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Gain introductory knowledge of Energy management and energy audit.
2.	Understand basic concepts of Energy conservation.
3.	Understand Energy efficiency and cost benefit.

Course Outcomes

At the end of the course, a student should be able to:

CO1.	Outline energy management system and related policies and Acts.
CO2.	Apply the concept of Energy Management in energy related issues.
CO3.	Work with energy management system and energy audit of whole system.
CO4.	Analyze energy conservation related to environmental issues.
CO5.	Carry out Auditing of relevant interdisciplinary systems.

SYLLABUS

Module 1: INTRODUCTION

Energy and Sources of energy, Energy consumption and GDP, Costs of exploration and utilization of resources, Energy pricing, Energy demand and supply, National energy plan, Need for Energy Policy, National and State level Energy Policies. Basic concepts of Energy Conservation and its importance, Energy Strategy for the Future, The Energy Conservation Act and its Features, Energy conservation in household, Transportation, Agricultural, Service and Industrial sectors, Lighting, HVAC Systems. (8L)

Module 2: ENERGY MANAGEMENT

History of Energy Management, Definition and Objective of Energy Management and its importance. Need of energy management, General Principles of Energy Management, Energy Management Skills, and Energy Management Strategy. Energy Management Approach. Understanding Energy Costs, Benchmarking, Energy performance, Matching energy usage to requirements, Maximizing system efficiency, Optimizing the input energy requirements, Fuel and Energy substitution. Organizing, Initiating and Managing an energy management program. Roles, responsibilities and accountability of Energy Managers. (8L)

Module 3: ENERGY AUDIT

Energy audit concepts, Definition, Need and Types of energy audit. Energy Audit Approach and Methodology. Systematic procedure for technical audit. Understanding energy audit costs, Benchmarking and Energy Performance. Energy audit based on First law and Second law of thermodynamics, Mass and Energy balances, Availability analysis, Evaluation of energy conserving opportunities, Economic analysis and life cycle costing. Duties and responsibilities of energy auditors. Energy audit instruments and their usage for auditing. Report-writing, preparations and presentations of energy audit reports. (8L)

Module 4: ENERGY CONSERVATION AND ENVIRONMENT

Energy conservation areas, Energy transmission and storage, Plant Lecture wise energy optimization Models, Data base for energy management, Energy conservation through controls, Computer aided energy management, Program organization and methodology. Energy environment interaction, Environmental issues, Global Warming, Climate Change Problem and Response, Carbon dioxide emissions, Depletion of ozone layer, Governments Regulations, Energy Economy interaction. Energy Conservation in Buildings, Energy Efficiency Ratings & ECBC (Energy Conservation Building Code). (8L)

Module 5: INTERDISCIPLINARY CASE STUDIES

Study of 4 to 6 cases of Energy Audit & Management in Industries (Mechanical, Chemical and other systems). (8L)

Text Books

1. Amlan Chakrabarti, Energy Engineering and Management, PHI, Eastern Economy Edition.
2. Smith CB, Energy Management Principles, Pergamon Press, New York.
3. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management & Case study, Hemisphere, Washington
4. L. C. Witte, P. S. Schmidt and D. R. Brown, Industrial Energy Management and Utilization, Hemisphere Publications, Washington.

Reference Books

1. W.R.Murphy, G.Mckay, Energy Management, Butterworths.
2. C.B.Smith Energy Management Principles, Pergamon Press.
3. L.C. Witte, P.S. Schmidt, D.R. Brown , Industrial Energy Management and Utilization, Hemisphere Publication, Washington
4. Archie, W Culp , Principles of Energy Conservation, McGraw Hill
5. Munasinghe, Mohan Desai, Ashok V, Energy Demand: Analysis, Management and Conservation, Wiley Eastern Ltd., New Delhi.

Course Evaluation:

Individual assignment, Seminar, Theory (Quiz and End semester) examinations

<u>Gaps in the syllabus (to meet Industry/Profession requirements)</u> :

Cost effective energy management

POs met through Gaps in the Syllabus: **PO3**

<u>Topics beyond syllabus/Advanced topics/Design:</u>

Advance energy auditing system

POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

<u>Direct Assessment</u>

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	3	-	2
CO2	1	2	3	-	2
CO3	1	2	3	-	2
CO4	1	2	3	-	2
CO5	1	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME585
Course title: Industrial Robotics
Pre-requisite(s): Engineering Mathematics, Engineering Mechanics.
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/II /05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Understand the kinematic design and dynamic formulation of a typical industrial robot.
2.	Foresee the possibilities in design uncertainties in kinematic model of a robot and make necessary changes in the modelling to make the controller perform precisely.
3.	Estimate the possible errors in dynamic forces/torques that may come on the actuators due to un-modelled parameters.
4.	Understand the parallel robot kinematic design and solve its inverse and forward kinematics.
5.	Evaluate a robot performance based on standard parameters.

Course Outcomes

At the end of the course, a student should be able to:

CO1.	Outline the structure of a typical robotic system, understand its link and joint parameters, and perform robot kinematics.
CO2.	Identify the geometric parameters of a serial robot by applying the knowledge of serial robot kinematics and generalized differential model of the robot.
CO3.	Identify the dynamic parameters of a serial robot by applying the knowledge of general form of dynamic equation of motion.
CO4.	Analyse planar and spatial parallel robots in context to its forward and inverse kinematics, and evaluate its singularity, condition number and manoeuvrability.
CO5.	Design a robotic manipulator and evaluate its primary and secondary workspace. Evaluate the performance of an industrial robot based on ISO standards.

SYLLABUS

Module 1:

Robotic systems - Its role in automated manufacturing; robot anatomy; classifications and specifications, Serial robot kinematics: forward and inverse, homogeneous transformations.
(8L)

Module 2:

Robot sensors, different types of contact and non-contact sensors; Robot vision and their interfaces. (8L)

Module 3:

Robot actuators and control; Pneumatic, hydraulic and electrical drives, controls used in robots. Robot end-effectors: mechanical, magnetic and vacuum grippers, gripping forces RCC and design features of grippers. (8L)

Module 4:

Robot languages and programming techniques. Performance analysis of Robots: Accessibility, Workspace of a robot manipulator: primary and secondary spaces, Orientation workspace, Local performances: Manipulability, Repeatability, Isotropy and Dexterity.
(8L)

Module 5:

Applications of robots in materials handling, machine loading/unloading, inspection, welding, spray painting and finish coating, and assembly, etc. Robot installation and planning. (8L)

Text Books

1. Industrial Robotic Technology - Programming and Application by M. P. Groover et. al., McGraw Hill
2. KS Fu, C. S. G Lee, R. Gonzalez, Robotics: Control, Sensing, Vision and Intelligence, McGraw-Hill Education, 1987.
3. S. K. Saha, Introduction to Robotics, McGraw Hill Education, 2008.

Reference Books

1. Bruno Siciliano and Oussama Khatib, Handbook of Robotics, Springer, 2016.
2. ISO 9283:1998 Manipulating industrial robots -- Performance criteria and related test methods, ISO, 1998.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):
Cost effective performance analysis of robots.
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Performance analysis of robots.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	2	3	2
CO2	3	3	3	3	2
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2,CD6
CO3	CD1,CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME586
Course title: Reliability in Design
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/II /05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Understand role of reliability evaluation.
2.	Identify reliability assessment techniques that may provide guidance for robust designs.
3.	Apply common concepts from statistics in design.
4.	Explore types of maintenance.
5.	Assess reliability of components and systems.

Course Outcomes

At the end of the course, a student should be able to:

CO1.	Perform reliability improvement and life tests.
CO2.	Recommend how further analysis, testing, or quality control may increase safety and efficiency of a structural design.
CO3.	Evaluate and apply statistical methods to structural design.
CO4.	Design for maintainability and its considerations.
CO5.	Formulate and solve reliability-based structural optimization problems.

SYLLABUS

Module 1: RELIABILITY BASICS

Basic Concepts of Reliability, Definition of Reliability, Role of Reliability evaluation, Design for reliability, Design under uncertainty, Why use probabilistic methods, Success stories, bath-tub-curve, system reliability, reliability improvement, maintainability and availability, Life tests, Acceptance sampling based on life tests. (8L)

Module 2: RELIABILITY IN DESIGN AND DEVELOPMENT

Introduction to Design of Experiments (DOE) and Taguchi Method, Failure mode and effects analysis, Basic symbols, Fault Tree construction and analysis, Monte Carlo Simulation, Human factors in design and design principles. (8L)

Module 3: RELIABILITY MANAGEMENT

Objectives of maintenance, types of maintenance, Maintainability, factors affecting maintainability, system down time, availability - inherent, achieved and operational availability (Numerical treatment). Introduction to Reliability Centered Maintenance. Design for maintainability and its considerations, Reliability and costs, Costs of Unreliability. (8L)

Module 4: SYSTEM RELIABILITY ANALYSIS

Reliability Improvement, Redundancy, element redundancy, unit redundancy, standby redundancy types of stand by redundancy, parallel components single redundancy, multiple redundancies (problems). (8L)

Module 5: LIFE TESTING & RELIABILITY ASSESSMENT

Censored and uncensored field data, burn-in testing, acceptance testing, accelerated testing, identifying failure distributions & estimation of parameters, reliability assessment of components and systems. (8L)

Text Books

1. Nikolaidis E., Ghiocel D. M., Singhal S., Engineering Design Reliability Handbook, CRC Press, Boca Raton, FL, 2004.
2. McPherson J.W., Reliability Physics and Engineering: Time to Failure Modeling, 2nd Edition, Springer, 2013.
3. Ebeling, C. E., An Introduction to Reliability and Maintainability Engineering, Waveland Press, Inc., 2009 (ISBN 1-57766-625-9).
4. Bryan Dodson, Dennis Nolan, Reliability Engineering Handbook, Marcel Dekker Inc, 2002.
5. Kapur, K. C., and Lamberson, L. R., Reliability in Engineering Design, John Wiley and Sons, 1977.

Reference Books

1. Reliability toolkit: Commercial practices edition. Reliability Analysis Center, 1995.
2. Blischke, Wallace R., and DN Prabhakar Murthy. Reliability: modeling, prediction, and optimization. Vol. 767. John Wiley & Sons, 2011.
3. Leemis, Lawrence M. Reliability: probabilistic models and statistical methods. Prentice-Hall, Inc., 1995.
4. Modarres, Mohammad, Mark P. Kaminskiy, and Vasiliy Krivtsov. Reliability engineering and risk analysis: a practical guide. CRC press, 2009.
5. O'Connor, Patrick, and Andre Kleyner. Practical reliability engineering. John Wiley & Sons, 2011.
6. Singiresu S Rao, Reliability Engineering, Pearson Education, 2014, ISBN: 978-0136015727.
7. Webpage : https://goremote.itap.purdue.edu/Citrix/XenApp/auth/login.aspx

Course Evaluation:

Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

Cost effective reliable design methods.

POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:

Advanced methods for reliable design.

POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	2	-	1
CO2	2	2	3	-	1
CO3	2	2	2	3	1
CO4	2	2	2	-	1
CO5	2	3	3	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2,CD6
CO3	CD1,CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6