JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTHAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING
M.Tech (ENERGY SYSTEMS)
(4 SEMESTER COURSE STRUCTURE AND SYLLABUS)

EFFECTIVE FROM THE YEAR 2015-16

I SEMESTER:

Subject Code	SUBJECT	L	P	C
15D32101	Energy Management	4	-	4
15D32102	Direct Energy Conversion Systems	4	-	4
15D32103	Renewable Energy Sources	4	-	4
15D32104	Applied Solar Energy Engineering	4	-	4
	ELECTIVE – I	4	-	4
15D32105	Energy Ecology & Environment			
15D32106	Design of Heat Transfer Equipment			
15D32107	Thermal & Nuclear Power Plants			
15D32108	Rapid Prototyping Technologies			
	ELECTIVE – II	4	-	4
15D32109	Reliability & Safety Engineering			
15D31110	Total Quality Management			
15D32110	Data Acquisition and Processing System			
15D32111	Creativity and Innovations in Design			
15D32112	Energy Utilization Lab	0	4	2
TOTAL		**24**	**4**	**26**

II SEMESTER :

Subject Code	SUBJECT	L	P	C
15D32201	Energy Conservation and Audit	4	-	4
15D32202	Waste Heat Recovery Systems	4	-	4
15D32203	Energy Efficient Electrical Systems	4	-	4
15D32204	Design of Wind Energy Systems	4	-	4
	ELECTIVE – III	4	-	4
15D32205	Optimization of Engineering Design			
15D32206	Refractory Systems			
15D32207	Solar Refrigeration & Air Conditioning			
15D32208	Product Planning and Marketing			
	ELECTIVE – IV	4	-	4
15D32209	Concurrent Engineering			
15D32210	Reverse engineering			
15D32211	Energy Resources			
15D32212	Maintenance Management			
15D54201	Research Methodology (Audit Course)	3	-	-
15D32213	Energy Operations Lab	0	4	2
TOTAL		**24**	**4**	**26**

Code	Subject	T	P	C
15D32301	**III Semester Seminar - I**	**0**	**4**	**2**
15D32401	**IV Semister Seminar - II**	**0**	**4**	**2**
15D32302	**III & IV Semester Project Work**	**--**	**--**	**44**
	Total	**24**	**8**	**48**

Note : All End Examinations (Theory and Practical) are of Three Hours Duration.

T – Tutorial L – Theory P- Practical / Drawing C - Credits

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2015-16

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DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech (ENERGY SYSTEMS)
(I SEMESTER COURSE STRUCTURE AND SYLLABUS)

EFFECTIVE FROM THE YEAR 2015-16

I SEMESTER :

Subject Code	**SUBJECT**	**L**	**P**	**C**
15D32101	Energy Management	4	-	4
15D32102	Direct Energy Conversion Systems	4	-	4
15D32103	Renewable Energy Sources	4	-	4
15D32104	Applied Solar Energy Engineering	4	-	4
	ELECTIVE – I	4	-	4
15D32105	Energy Ecology & Environment			
15D32106	Design of Heat Transfer Equipment			
15D32107	Thermal & Nuclear Power Plants			
15D32108	Rapid Prototyping Technologies			
	ELECTIVE – II	4	-	4
15D32109	Reliability & Safety Engineering			
15D31110	Total Quality Management			
15D32110	Data Acquisition and Processing System			
15D32111	Creativity and Innovations in Design			
15D32112	Energy Utilization Lab	0	4	2
TOTAL		**24**	**4**	**26**

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

I- SEMESTER **L P C**

4 - 4

ENERGY MANAGEMENT
(15D32101)

UNIT - I

ENGINEERING ECONOMICS:

Managerial objectives - steps in planning- Capital budgeting- Classification of costs- Interest- Types- Nominal and effective interest rates Discrete and continuous compounding - discounting - Time value of money - Cash flow diagrams - Present worth factor, Capital recovery factor, Equal annual payments - Equivalence between cash flows.

UNIT - II

DEPRECIATION & COST ANALYSIS:

Aims-Physical depreciation-Functional depreciation- Methods of depreciation-Straight line method, Declining balance method, Sum of years digits method, Sinking fund method, Service output method- Capital recovery with return-Service life estimation- Morality curves. Break even analysis and break even chart- Minimum cost analysis- Benefit cost analysis- Life cycle cost analysis.

UNIT - III

PROJECT MANAGEMENT:

Methods of investment appraisal- Rate of return method, Payback period method, Net present value method (NPV)- Internal Rate of Return method(IRR)- Adoption of the methods in energy conservation campaign- Types of projects- Purpose of project management - Classification – Role and qualities of project manager - Types of budgets - Budget committee – budgeting.

UNIT - IV

ENERGY MANAGEMENT PROGRAMS:

Necessary steps of energy management programmer - Concepts of Energy management - General principles of energy management – Energy management in manufacturing and process industries- Qualities and functions of Energy manager - Language of Energy manager-Checklist for top management.

UNIT - V

ENERGY POLICY, SUPPLY, TRADE& PRICES:

Energy resources in India – level of power generation – transmission & distribution of power. Indian energy policy,Energy trade & its economic impacts – domestic energy production – Energy transformation & distribution & energy self sufficiency. International & National crude oil prices – domestic fuel prices – natural gas, LPG, kerosene and firewood - pricing policy.

BOOKS:

1. Albert Thumann, Handbook of Energy Audits, The Fairmont Press Inc., Atlanta gergia, 1979.
2. Murphy W.R and Mckay G, Energy Management, Butterworths, London, 1982.
3. Albert Thumann, Plant Engineer and Management guide to Energy Conservation, Van Nost and Reinhold Co., Newyork.
4. Energy Audits, E.E.O.-Book-lets, U.K. 1988.
5. Craig B.Smith, "Energy Management Principles", Pergamon Press.
6. The role of Energy Manager, E.E.O., U.K.
7. The Energy conservation Design Resource Hand Book-The Royal architectural Institute of Canada.
8. Energy Management Hand Book-Ed. By Wayne C. Turner, John Wiley and sons, 1982.

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DEPARTMENT OF MECHANICAL ENGINEERING
M.Tech: ENERGY SYSTEMS

I- SEMESTER **L P C**
4 - 4

DIRECT ENERGY CONVERSION SYSTEMS
(15D32102)

UNIT-I

Energy Balance of the earth – The Greenhouse effect – Physical Source of sunlight – Planck's black-body radiation distribution from different black body temperatures – The earth and Solar Constant – Spectral distribution of extra-terrestrial radiation – Basic earth-sun angles – Solar time and equation of time – attenuation of solar radiation by the atmosphere – Direct and diffuse radiation at the ground – Empirical equations for predicting the availability of solar radiation.

UNIT-II

Photovoltaics (PV): Semiconductor physics and Operating principle – Silicon as PV material - Direct and indirect band-gap material – Flow of Silicon material – Single crystal Silicon Solar cell – Structure – Important electrical parameters – Ideal and approximate equivalent circuits - Manufacturing processes (wafer and cell) of single crystal, multi-crystalline and Edge Defined Film Fed Growth Silicon - Temperature and Irradiation effects – Absorption coefficient and reflectance - Silicon film, Cadmium telluride (cdTe), Copper Indium Gallium Diselenide, amorphous silicon – Comparison of 'Thin film' and 'Bulk crystal' technology – manufacturing (module making) processes of amorphous silicon on glass, stainless steel and plastic substrates – Typical materials used - Concentrator technology and the importance of tracking – Comparison of efficiencies of various technologies – Recent trends in PV technology and manufacturing.

UNIT-III

PV modules and Arrays – Design requirements of PV modules – Rating of PV modules – Standard Test Conditions (STC), Normal Operating Cell Temperature (NOCT) and Standard Operating Conditions (SOC) – Output curves ('Current-Voltage' or 'I-V' and 'Power-Voltage' or 'P-V') under various irradiance and temperature conditions – Mounting structure for PV modules/arrays – Orientation and array layout – Effects of shading - Other balance of systems (BOS) and protective devices: blocking and bypass diodes, movistors – Roof mounted arrays – Building integrated PV (BIPV) – Typical faults and diagnosis – Hot Spot problem in a PV module and safe operating area - Performance measurement of typical parameters of cells/modules under natural and simulated light – Indoor sun simulators - Outdoor PV array testers – ASTM and IEEE standards for Class A and Class B simulators – Pulsed, steady state and single flash types – Determination of temperature coefficients, series and shunt resistances, curve correction factor - Computation of efficiency and fill factor – Translation of parameters actually measured to STC – Reliability Testing: Qualification tests, IEC Standards 61215 & 61646 – Reliability test – Field stress testing

UNIT-IV

PV Systems – Stand alone and grid connected – Load estimation – Daily load demand – Solar radiation/irradiance table for a particular location - Sizing of the PV array, battery, inverter and other BOS – Maximizing efficiency of sub-systems – Balance of systems – Single axis and two axis tracking at optimum inclination of the PV array – Power conditioning and control – Maximum Power Point Trackers, Charge controllers/regulators, AC/DC Converters, DC/AC inverters – Alarms, indicators and monitoring equipment – Energy Storage: Batteries, Deep cycle lead acid type, Battery Design and construction, Other types of batteries, Battery Selection criteria, Safety issues – Typical applications of PV – Hybrid systems: PV-Wind, PV-Diesel engine, PV-Mains - System Sizing examples: Domestic loads, Water pumping, Lighting (using CFLs, White LEDs) - hybrid systems, village power packs – Installation practices – Trouble shooting – Economic analysis: Life Cycle Cost analysis – Environment impacts of PV – Green buildings – Potential for GHG emission reduction of installed PV systems

UNIT-V

The Hydrogen Economy – Advantages of hydrogen as an energy carrier – Components of the hydrogen economy - Generation of hydrogen - Transport and storage of hydrogen: physical and chemical - Fuel Cells – Classification of fuel cells based on (a) Type of electrolyte (b) Type of the fuel and oxidant (c) operating temperature (d) application and (e) chemical nature of electrolyte

Reference Books:

a. Solar Electricity /Edited by Tomas Markvart/John Wiley and Sons
b. Solar Cells – Operating Principles, Technology and System Applications /Martin A. Green/Prentice Hall Inc
c. Modelling Photovoltaic Systems using P Spice/Luis Castaner and Santiago Silvestre/John Wiley and Sons
d. Solar Energy – Fundamentals and Applications/H.P. Garg and J. Prakash/Tata McGraw-Hill
e. Generating Electricity from the Sun/Edited by Fred C. Treble/Pergamon Press
f. Amorphous Silicon Solar Cells/K.Takahashi and M.Konagai/North Oxford Academic
g. Photovoltaic Systems Engineering/Roger Messenger/CRC Press
h. Fuel Cells/Livin Oniciu/Abacus Press 1976

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DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

I- SEMESTER **L P C**

4 - 4

RENEWABLE ENERGY SOURCES
(15D32103)

UNIT – I

SOLAR ENERGY:

Availability of solar energy, Measurement of sunshine, solar radiation data, estimation of average solar radiation, the black body, absorptance and emittance, Kirchoff's law. Reflection from surfaces, Solar energy selection, selective surfaces, Construction of solar flat plate and evacuated tube collectors, Performance of solar energy collectors, Solar heating and cooling.

UNIT – II

WIND ENERGY:

Wind mills and wind turbine systems, Classification of wind machines: Horizontal & Vertical axis configuration. High and low solidity rotors, Elements of wind mills and wind turbine systems, Aerodynamic models, Rankine Froud Actuator disc model, Betz limit, angular momentum wake rotation theory, Aerofoil sections and their characteristics, Estimation of power output and energy production.

UNIT – III

OCEAN THERMAL ENERGY:

Ocean thermal energy sources, Ocean thermal energy power plant development, Closed and open cycles. Advantages and operating difficulties.

TIDAL & WAVE ENERGY

Tidal power sources, Conventional and latest design of tidal power system, The ocean wave, Oscillating water column (Japanese) and the Dam, Atol design.

UNIT – IV

GEOTHERMAL ENERGY :

Earth as source of heat energy, stored heat and renewability of earth's heat, Nature and occurrence of geo thermal field, Classification of thermal fields, Model of Hyper thermal fields & Semi thermal fields, drilling hot water measurements.

UNIT – V

FUEL CELL ENERGY:

Description, properties and operation of fuel cells, Major components & general characteristics of fuel cells, Indirect methanol fuel cell systems. Phosphoric acid fuel cell systems and molten carbonate fuel cell systems.

BIOMASS ENERGY:

Types of conversion techniques for the production of solid, liquid and gaseous fuels by chemical and biochemical methods, and Biomass gasifiers- Selection of a model and size, Technical, Climatic, geographical and economic issues.

BOOKS:

1. Principles of Solar Engineering: F.Kreith&J.F.Krieder/Mc.Graw Hill Book Co
2. Wind Energy conversion Systems: L.C.Freris, Prentice Hall, Inc..
3. Non-conventional Energy Sources: G.D. Rai
4. Energy Technology: S. Rao & B.B. Parulekar
5. Geo thermal energy: H.Christopher&H.Armstead.
6. Photo Voltaic Energy Systems, Design&Applications: Mathew Buresch, Mc Graw Hill Book Co..
7. Bio Gas Technology, A Practical Hand Book: K.C.Khendelwal&S.S.Mahdi Mc Graw Hill Book Co..
8. Hand Book of Batteries and Fuel cells: David Linden, Mc Graw Hill Book Co..
9. Energy Conversion Systems: H.A.Sorenson: John Wiely & S.jons
10. Renewable Energy Sources & Conversion technology: Bansal.K: Leemann&Meliss
11. Energy technology Hand Book: EdD.M.Considine
12. Principles of energy conversion AW.Culp

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DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

I- SEMESTER **L P C**

4 - 4

APPLIED SOLAR ENERGY ENGINEERING
(15D32104)

UNIT – I

SOLAR RADIATION:

Sources of radiation –sun earth relationship, Solar Time and angles, day length, angle of incidence on tilted surface; Sun path diagram, Solar Radiation: Extraterrestrial Radiation; Effect of earth atmosphere; Estimation of solar radiation on horizontal and tilted surfaces.
Geographic Distribution of solar radiation, Phyrellio, pyranometer, equation of time-estimation of average radiation falling on tilled.

UNIT-II

SOLAR ENERGY TECHNOLOGIES:

Performance analysis of a liquid Flat-plate collector, Total loss coefficient and heat losses: Top loss coefficient, Bottom loss coefficient, Side loss coefficient. Solar concentrating collectors, types of concentrating collectors, Parabolic Dish System, The central power tower system, The Parabolic Trough System, Tracking CPC and Solar Swing, Performance analysis of cylindrical parabolic collector, Compound parabolic concentrator (CPC).

UNIT-III

SOLAR CELLS:

Solar cell fundamentals, solar cell classification, solar cell, module, panel array construction, maximum power pint trackers(MPPT), solar PV applications, The Recent developments in Solar cells, Role of Nano-Technology in Solar cells.

UNIT – IV

ECONOMICS:

Discounted Cash Flow-light cycle, coasting of solar system, production function and optimization

UNIT – V

THERMAL POWER:

The power concepts- design aspects, thermo-chemical reactor.

SOLAR POND AND SOLAR STILLS:

Working Principle-Construction-operating difficulties and remedies, Agriculture and Domestic applications: Still, timber drying, crop drying, cooker.

Reference Books:

1. Solar Energy Thermal Process Diffice and Beckman
2. Solar Heating and Cooling by Kreith and Kreider
3. Solar Energy Utilization by G.D.Rai
4. Solar Energy Utilization by G.D.Rai , Khanna Publishers.
5. Renewable Energy Sources and Emerging Technologies- By D.P. Kothari, PHI Pub.,
6. Applied Solar Energy by Meinel and Meinel
7. Non-Conventional Energy Resources by B.H . Khan, Tata McGraw Hill
8. Energy Resources Utilization and Technologies By Anjaneyulu, BS Pub.,

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

I- SEMESTER **L P C**

4 - 4

ENERGY ECOLOGY & ENVIRONMENT (Elective – I)
(15D32105)

UNIT-I

Energy source for earth – sun – its radiation – its absorption and reflection. Various renewable and non-renewable resources.

UNIT-II

Boisphere – Energetics of the biosphere – Concepts of Ecology – Components of Ecosystems.

UNIT-III

Energy transactions in biosphere – photo synthesis and producers – Herbivones – Carnivones – decomposers – Energy transfers & food wells.

UNIT-IV

Dependence on abiotic systems – biogeochemical cycles. Elements of Environment – Interrelationships in environmental components.

UNIT-V

Concepts of pollution and affecting the natural balances in energy systems. Energy concepts for a sustainable world bio – systems.

REFERENCE BOOKS:

1. Renewable Energy, Environment and Development, Maheshwar Dayal, Konark Publishers Pvt. Ltd.,
2. Ecology and Environment, P.D. Sharma Rastogi Publications.
3. Energy for a sustainable world, J.Goldenberg, T.B. Johnson, Amulya K.Reddy & Robert Williams Willey Eastern Ltd.,

Concepts of Ecology, E.J.Kormondal , Prentice Hall India Ltd.,

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

I- SEMESTER **L P C**

4 - 4

DESIGN OF HEAT TRANSFER EQUIPMENT (ELECTIVES-I)
(15D32106)

UNIT - I

DESIGN OF HEAT EXCHANGERS:

Heat Exchangers-mean temperature differences for parallel and counter flow- effectiveness method (N.T.U)

DESIGN OF CONDENSERS:

Overall heat transfer coefficients- temperature distribution and heat flow in a condenser-pressure drop in a condenser –extended fin surfaces-consideration of fouling factor-L.M.T.D. correction factor.

UNIT - II

DESIGN OF EVAPORATORS:

Temperature distribution and heat flow in an evaporator-pressure drop- factor to be consider in the design of heat transfer equipment-types of heat consideration of fouling factor – correction factor

DESIGN OF COMPRESSORS:

Types-equivalent shaft work-volumetric efficiency-factors affecting total volumetric efficiency –compound compression with inter cooling- rotary compressors-surging.

UNIT - III

DESIGN OF COOLING TOWERS AND SPRAY PONDS:

Classification-performance of cooling towers – analysis of counter flow cooling towers-enthalpy-temperature diagram of air and water- cooling ponds- types of cooling ponds –cross flow cooling towers- procedure for calculation of outlet conditions.

UNIT - IV

DESIGN OF DUCTS:

Continuity equation-Bernoulli’s equation-pressure losses-frictional charts- coefficient of resistance for fillings- duct sizing methods.

DESIGN OF FANS:

Standard air-fan horsepower-fan efficiency-similarity laws-fan laws-performance coefficients- theoretical expression for total pressure drop by a fan-centrifugal fan- axial flow fan-system resistance.

UNIT - V

PIPING SYSTEM:

Requirements of a good piping system-pressure drop in pipes-moody chart-refrigerant piping-discharge line-liquid line-suction line-piping arrangement

REFERENCE BOOKS:

1. Heat and mass transfer by Arora & Domkundwar.
2. Refrigeration & Air-Conditioning by P.L.Ballaney
3. .Refrigeration & Air-Conditioning by C.P.Arora.
4. .Refrigeration & Air-Conditioning by Stoecker

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

I- SEMESTER **L P C**

4 - 4

THERMAL AND NUCLEAR POWER PLANTS (ELECTIVES: I)
(15D32107)

UNIT - I:

Introduction:

Steam Power Plants: Introduction – General Layout of Steam Power Plant, Basic Steam Cycles: Rankine cycle, Mean temperature of heat addition, Regeneration, Reheat cycles, cogeneration, Efficiencies and Optimization, Modern Coal-fired Steam Power Plants, Power Plant cycles.

Fuel handling, Combustion Equipment, Ash handling, Dust Collectors.

Steam Generators: Types, Accessories, Feed water heaters, Performance of Boilers, Water Treatment, Cooling Towers, Steam Turbines, Compounding of Turbines, Steam Condensers, Jet & Surface Condensers.

UNIT - II:

Gas Turbine Power Plant: Cogeneration, Combined cycle Power Plants, Analysis and Performance of Gas Turbine Plant, Waste-Heat Recovery, IGCC Power Plants, Fluidized Bed Combustion – Advantages & Disadvantages, Principle components of Gas Turbine plant, Fuels and Materials Used for Gas Turbine Power plant.

UNIT -III:

Nuclear Power Plants: Nuclear Physics, Nuclear Reactors, Classification – Types of Reactors, Site Selection, Methods of enriching Uranium, Applications of Nuclear Power Plants.

Nuclear Power Plants Safety: By-Products of Nuclear Power Generation, Economics of Nuclear Power Plants, Nuclear Power Plants in India, Future of Nuclear Power.

UNIT -IV:

Economics of Power Generation: Factors affecting the economics, Load Factor, Utilization factor, Performance and Operating Characteristics of Power Plants. Economic Load Sharing, Depreciation, Energy Rates, Criteria for Optimum Loading, Specific Economic energy problems.

UNIT - V:

Power Plant Instrumentation and Pollution: Classification, Pressure measuring instruments, Temperature measurement and Flow measurement. Analysis of Combustion gases, Pollution – Types, Methods to Control.

TEXT BOOKS:

1. Power Plant Engineering / P.K. Nag / TMH.
2. Power Plant Engineering / R.K. Rajput / Lakshmi Publications.
3. Power Plant Engineering / P.C.Sharma / Kotaria Publications.
4. Power Plant Technology / Wakil./TMH

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING
Common to (M.Tech – ENERGY SYSTEMS & PRODUCT DESIGN)

I- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

RAPID PROTOTYPING TECHNOLOGIES (Elective – I)
(15D32108)

UNIT-I

Introduction: Need for the compression in product development, History of RP systems, Survey of applications, Growth of RP industry and classification of RP systems.

Stereo Lithography Systems: Principle, Process parameter, Process details, Data preparation, Data files and machine details, Application.
Selective Laser Sintering: Type of machine, Principle of operation, Process parameters, Data preparation for SLS, Applications.

UNIT-II

Fusion Deposition Modelling: Principle, Process parameter,Path generation, Application
Solid Ground Curing: Principle of operation, Machine details, Applications.

UNIT-III

Laminated Object Manufacturing: Principle Of Operation, LOM materials.
Process details, application.

Concepts Modelers: Principle, Thermal jet printer, Sander's model market, 3-D printer. Genisys Xs printer HP system 5, Object Quadra systems.

UNIT-IV

LASER ENGINEERING NET SHAPING (LENS)

Rapid Tooling: Indirect Rapid tooling -Silicon rubber tooling –Aluminum filled epoxy tooling Spray metal tooling, Cast kirksite, 3Q keltool, etc, Direct Rapid Tooling Direct. AIM, Quick cast process, Rapid Tool, DMILS, Prometal, Sand casting tooling, Laminate tooling soft, Tooling vs. hard tooling.

UNIT-V

Rapid Manufacturing Process Optimization: Factors influencing accuracy, Data preparation errors, Part building errors, Error in finishing, Influence of build orientation.

Allied Processes: Vacuum casting, surface digitizing, Surface generation from point cloud, Surface modification-data transfer to solid models.

TEXT BOOKS:

1. Rapid Prototyping and Tooling by Hari Prasad & K.S. Badhrinarayan/ Page Turners
2. Paul F. Jacobs- "**Stereo lithography and other RP & M Technologies**", SME, NY 1996.
3. Flham D.T & Dinjoy S.S - "**Rapid Manufacturing**" Verlog London 2001.
4. Lament wood, "**Rapid automated",** Indus press New York

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

I- SEMESTER **L P C**

4 - 4

RELIABILITY & SAFETY ENGINEERING (ELECTIVES: II)
(15D32109)

UNIT - I

Elements of probability theory, probability of union and intersection of events, mutually exclusive events, statistical independence, random variables, PDF and CDF, binomial, Poisson and Gaussian distributions.

Component reliability-definition of reliability and hazard functions, failure distributions, exponential Weibull and gama distributions, uniform distribution, bath tub curve.

UNIT - II

Reliability of non-repairable systems, reliability network, series, parallel and rout of configurations, decomposition method, cut set & tie set method , methods of improving reliability.

UNIT - III

Maintainability and availability, MTBF and MTTR, probability and frequency of failure, state space analysis, Markov process, steady state probability, and dependent failures.

Failure types and causes of failure- failure classification, case studies, human factors analysis of different causes of failures.

UNIT - IV

Fault detection, non-destructive testing, X-ray and Gamma ray radiography, Xerography, Electro magnetic methods, ultrasonic methods.

UNIT - V

Monitoring techniques Signature analysis-vibration and noise monitoring, faults and vibration modes, permissible limits of vibrations, temperature monitoring, infrared camera. Wear monitoring, analysis of wear partials, ferography, spectroscopic analysis, performance trend monitoring.

BOOKS:

1. “Reliability engineering” By Balaguruswamy.
2. “Testing and inspection of materials” by H.E.Davies.
3. “Instrumentation, Measurement and analysis” by Prof.B.C.NaKra
4. “Mechanical fault diagnosis” By R.A.Collacolt.

REFERENCE:

1. Maintenance Engineering Hand Book

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DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

I- SEMESTER **L P C**

4 - 4

TOTAL QUALITY MANAGEMENT (ELECTIVES: II)
(15D31110)

UNIT – I

TQM – Overview, Concepts, Elements – History-Quality Management Philosophies-Juran, Deming, Crosby , Feigenbaum, Ishikawa– Stages of Evolution– Continuous Improvement – Objectives – Internal and External Customers. Quality Standards – Need for Standardization - Institutions – Bodies of Standardization, ISO 9000 series – ISO 14000 series – Other Contemporary Standards – ISO Certification Process-Third Party Audit

UNIT – II

Process Management- Quality Measurement Systems (QMS) – Developing and Implementing QMS –TQM Tools & Techniques- 7 QC Tools- 7 New QC Tools.
Problem Solving Techniques - Problem Solving Process – Corrective Action – Order of Precedence– System Failure Analysis Approach – Flow Chart – Fault Tree Analysis – Failure Mode Assessment and Assignment Matrix – Organizing Failure Mode Analysis – Pedigree Analysis.

UNIT – III

Quality Circles – Organization – Focus Team Approach – Statistical Process Control – Process Chart – Ishikawa Diagram – Preparing and using Control Charts.

UNIT – IV

Quality Function Development (QFD) – Elements of QFD – Benchmarking-Types-Advantages & Limitations of Benchmarking – Taguchi Analysis – Loss function - Taguchi Design of Experiments, Robust Design, Poka-yoke, Kaizen, Deming Cycle.

UNIT – V

Value Improvement Elements – Value Improvement Assault – Supplier Teaming; Business Process Reengineering & Elements of Supply Chain Management. Six Sigma Approach – Application of Six Sigma Approach to various Industrial Situations.

TEXT BOOKS:

1Total Quality Management,DakhBesterfield, Pearson Edu.
2. Total Quality Management, K.ShridharBhat, Himalaya.

REFERENCE BOOKS:

1. Quality management, Howard Giltow-TMH
2. Quality management, Evans.
3. Quality management, Bedi

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

I- SEMESTER **L P C**

4 - 4

DATA ACQUISITION & PROCESSING SYSTEMS (ELECTIVES: II)
(15D32110)

UNIT - I

TRANSDUCERS:

Basic requirements of a transducer- principle of operation, application of strain gauges, capacitive, Inductive, Photoelectric, piezoelectric & Potentiometer transducers. Resistance thermometers, thermocouples, hermistors, photoconductive & photovoltaiccells, and Electromagnetic& Turbine type flow meters.

UNIT - II

DATA REPRESENTATION:

Number systems: Decimal, Binary, Octal, Hexadecimal and conversion from one One system to the others; Logic Gates: AND, OR, NOT, NAND, NOR, EX-OR, EX-NOR gates; Logic circuit Implementation: 'Sum of products and product of sums' Boolean equations; Boolean algebra: postulates, theorems and simplification of Boolean equations; Binary arithmetic: Addition, subtraction Circuits; Digital codes: BCD, XS-3, Gray, 2421 and ASCII codes, BCD to decimal decoders; parity checkers and generators.

DIGITAL CIRCUITS

Flip Flops: R-S, JK ,D, Master-slave, Latches – Timing Diagrams – Registers, Buffer, shift and controlled shift registers- Counters-ripple, synchronous, ring and Presettable counters; Astable and monostable multivibrators.

UNIT - III

MEMORIES &PROCESSORS:

Memories: ROMs, PROMs, EPROMs and RAMs, expanding memory size; Processors: arithmetic Logic Unit, register array- control unit, memory, input/output, system concepts, hardware & software, and low-level& high-level languages.

INSTRUMENTATION SYSTEMS:

Representation of generalized data acquisition system; single and multi channel data acquisition systems; microprocessor based data logger; microprocessor control of petrol engine.

UNIT - IV

COMPUTING SYSTEMS:

Simple computing: architecture, instruction set. Fetch & execution cycles, and Microprogramming-Advanced computing- architecture, memory & reference instructions. register instructions, jump& call instruction. Arithmetic instructions, Increments/decrements & rotates, logic instructions. Arithmetic & logic immediates, jump instructions. Extended register instructions indirect instructions. -Simple programming.

INTEL 8085 MICROPROCESSOR:

The 8085:block diagram:pinout diagram. additional instructions. minimum system and timing diagrams; I/O operations: programmed I/O, interrupt driven I/O and Direct memory access

UNIT - V

DATA CONVERSION:

Digital to analog conversion: weighted resistor; and R-2Rladder D/A converters; Analog to digital conversion: successive approximation. Single dual slope integration, and parallel conversion A/D converters, A/D converters using voltage to frequency &voltage to time conversion; sample and hold circuits; multiplexing: D/A and A/D multiplexing; de multiplexing.

BOOKS:

1. Electronic Instrumentation & Measurement Techniques: Willman David Cooper, Prentice-Hall of India pvt-ltd.,
2. Instrumentation Devices and Systems: Csrangan, OR Sharma and V.S.V Muni; Tata McGraw-Hill Publishing CO. Ltd..
3. Integrated Digital Electronics; Walter A.Triebel; Printice Hall..Iinc..
4. Modern Digital Electronics: R.P. Jain,Tata Mc Graw-Hill Publishing Co., ltd..
5. Digital Computer Electronics, An Introduction To Microcomputers: Albert.Paull, Malvino;Tata Mc Graw-Hill Publishing Co.,Ltd.,

JNTUACEA **R15**

2015-16

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU

DEPARTMENT OF MECHANICAL ENGINEERING

Common To M.Tech – PRODUCT DESIGN & ENERGY SYSTEMS

I- SEMESTER **L P C**

4 - 4

CREATIVITY AND INNOVATIONS IN DESIGN (Elective – II)

(15D32111)

UNIT I INTRODUCTION

Need for design creativity – creative thinking for quality – essential theory about directed creativity

UNIT II MECHANISM OF THINKING AND VISUALIZATION

Definitions and theory of mechanisms of mind heuristics and models : attitudes, Approaches and Actions that support creative thinking - Advanced study of visual elements and principles- line, plane, shape, form, pattern, texture gradation, color symmmetry.Spatial relationships and compositions in 2 and 3 dimensional space - procedure for genuine graphical computer animation – Animation aerodynamics – virtual environments in scientific Visualization – Unifying principle of data management for scientific visualization – Unifying principle of data management for scientific visualization - Visualization benchmarking

UNIT III CREATIVITY

Methods and tools for Directed Creativity – Basic Principles – Tools of Directed Creativity – Tools that prepare the mind for creative thought – stimulation of new ideas – Development and Actions: - 16 Processes in creativity ICEDIP – Inspiration, Clarification, Distillation, Perspiration, Evaluation and Incubation – Creativity and Motivation The Bridge between man creativity and the rewards of innovativeness – Applying Directed Creativity to the challenge of quality management

UNIT IV DESIGN

Process Design, Emotional Design – Three levels of Design – Viceral, Behavioral and Reflective-Recycling and availability-Creativity and customer needs analysis – Innovative product and service designs, future directions in this application of creativity thinking in quality management

UNIT V INNOVATION

Achieving Creativity – Introduction to TRIZ methodology of Inventive Problem Solving - the essential factors – Innovator‟s solution – creating and sustaining successful growth – Disruptive Innovation model – Segmentive Models – New market disruption - Commoditation and DE-commoditation – Managing the Strategy Development Process – The Role of Senior Executive in Leading New Growth – Passing the Baton

REFERENCES

1. Rousing Creativity: Think New NowFloydHurr, ISBN 1560525479, Crisp Publications Inc. 1999
2. Geoffrey Petty," how to be better at Creativity", The Industrial Society 1999
3. Donald A. Norman," Emotional Design", Perseus Books Group New York , 2004
4. Clayton M. Christensen Michael E. Raynor," The Innovator‟s Solution", Harvard Business School Press Boston, USA, 2003
5. Semyon D. Savransky," Engineering of Creativity – TRIZ", CRC Press New YorkUSA," 2000

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

I- SEMESTER **L P C**
0 4 2

ENERGY UTILIZATION LABORATORY
(15D32112)

List of Experiments

S.No.	Experiment Name
1.	Survey of alternative Energy Sources
2.	Estimation of energy Saving by Solar Water Heating
3.	Flat-Plate Collector Requirement Calculations
4.	Estimation of Discharge of Centrifugal pump using Solar Power
5.	Demonstration of Wind Tunnel
6.	Study of Biomass plant
7.	Study of Bio-Gasifier
8.	Performance of Solar Cocker

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

L	P	C
4	-	4

EFFECTIVE FROM THE YEAR 2015-16

II SEMESTER:

Subject Code	SUBJECT	L	P	C
15D32201	Energy Conservation and Audit	4	-	4
15D32202	Waste Heat Recovery Systems	4	-	4
15D32203	Energy Efficient Electrical Systems	4	-	4
15D32204	Design of Wind Energy Systems	4	-	4
	ELECTIVE – III	4	-	4
15D32205	Optimization of Engineering Design			
15D32206	Refractory Systems			
15D32207	Solar Refrigeration & Air Conditioning			
15D32208	Product Planning and Marketing			
	ELECTIVE – IV	4	-	4
15D32209	Concurrent Engineering			
15D32210	Reverse engineering			
15D32211	Energy Resources			
15D32212	Maintenance Management			
15D54201	Research Methodology (Audit Course)	3	-	-
15D32213	Energy Operations Lab	0	4	2
TOTAL		**24**	**4**	**26**

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

II- SEMESTER **L P C**
4 - 4

ENERGY CONSERVATION AND AUDIT
(15D32201)

UNIT - I

THERMODYNAMICS

Availability, energy and Anergy-Exergy, energy, entropy relationship- Degradation of energy – exergy analysis- exergy conservation- combustion, thermal efficiency, thermal losses; thermal balance sheets.

HEAT EXCHANGER THEORY:

Types Of heat exchangers - overall heat transfer coefficient – fouling factor - Design of heat Exchangers, L.M.T.D. and N.T.U. methods.

UNIT - II

ENERGY CONSERVATION:

Rules for efficient energy conservation – technologies for energy conservation – outline of waste heat and material reclamation, load management.

ENERGY AUDITING:

A definition- Level of responsibility- Control of Energy- Uses of Energy - Energy index - Cost index - Pie charts-sankey diagrams Load profiles - Types of energy audits- General energy audit- Detailed energy audit.

UNIT - III

THERMAL INSULATION & REFRACTORIES:

Heat loss through un insulated and insulated surfaces; effect of insulation on current carrying wires – economic thickness of insulation – critical radius of insulation – properties of thermal insulators – classification of insulation materials – classification of refractories – properties of refractories – Criteria for good refractory material – application of insulating & refractory materials.

UNIT - IV

WASTE HEAT RECOVERY SYSTEMS:

Guideline to identify waste heat – feasibility study of waste heat – shell and tube heat exchangers – Thermal wheel – heat pipe heat exchanger – Heat pump – waste heat boilers – Incinerators.

UNIT - V

HEAT RECOVERY SYSTEMS:

Liquid to liquid heat exchangers – regenerators, recuperaters, rotating regenerators – selection of materials for heat exchangers, U- tube heat exchanger, fluidized bed heat exchanger –economizer.

References :

1. The role of Energy Manager, E.E.O., U.K.
2. The Energy conservation Design Resource Hand Book-The Royal architectural Institute of Canada.
3. Conduction Heat Transfer- -Schneder Addition Wieslthy
4. Conduction of Heat in Solids -Carslaw & Jaeger.
5. Fundamentals of heat and mass transfer -R.C. Sachdev New Age International Publishers
6. Heat Transfer By R.K. Rajput/ laxmi publication

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

II- SEMESTER **L P C**
4 - 4

Waste Heat Recovery Systems
(15D32202)

UNIT-I

Introduction

Rankine Cycle, Coupled cycles and combined plants, Energy resources and use, Potential for energy conservation, Optimal utilization of fossil fuels. Total energy approach.

UNIT-II

Waste Heat Recovery Systems

selection criteria for waste heat recovery technologies - recuperators - Regenerators - economizers - plate heat exchangers - thermic fluid heaters - Waste heat boilers- classification, location, service conditions, design Considerations - fluidized bed heat exchangers - heat pipe exchangers - heat pumps – sorption systems.

UNIT-III

Prime Mover Exhausts; incineration plants; heat pump systems; thermoelectric devices. Utilization of low grade reject heat from power plants, Utilization of waste heat in refrigeration, heating, ventilation and air conditioning systems. Thermoelectric system to recover waste heat.

UNIT-IV

Energy Storage Systems:

Need for energy storage, Thermal, electrical, magnetic and chemical storage systems.

UNIT-V

Economic Analysis

Investment cost – economic concepts – measures of economic performance – procedure for economic analysis – examples – procedure for optimized system selection and design – load curves - sensitivity analysis – regulatory and financial frame work for cogeneration and waste heat recovery systems

REFERENCES:

[1] Goswami, D. Y., and Kreith, F. Energy Conversion . CRC Press, 2007.
[2] Hewitt, G. F., Shires, G. L., and Bott, T. R. Process Heat Transfer . CRC Press, Florida, 1993.
[3] Li, K. W., and Priddy, A. P. Power Plant System Design . John Wiley and Sons, New York, 1985.
[4] Nag, P. K. Power Plant Engineering . Tata McGraw-Hill, New Delhi, 2001.
[5] El-Wakil, Power Plant Engineeirng, Mcgraw-Hill
[6] HoSung Lee, Thermal Design
[7] Dincer, Rosen, Thermal Energy Storage Systems

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

II- SEMESTER **L P C**
4 - 4

ENERGY EFFICIENT ELECTRICAL SYSTEMS
(15D32203)

UNIT - I

THREE PHASE INDUCTION MOTROS:

Cage motors-equivalent circuit-speed-torque characteristics-performance characteristics-voltage unbalance-over motoring-slip ring induction motor characteristics multi speed motors.

SINGLE PHASE INDUCTION MOTORS:

Starting & running performance-split phase-capacitor type motor-characteristics-reluctance motor.

UNIT - II

ENERGY EFFICIENT MOTORS:

Constructional details-factors affecting efficiency-losses distribution-characteristics-calculation of pay back period.

ECONOMICS OF POWER FACTOR IMPROVEMENT:

Simple pay back method-return on investment-life cycle analysis.

UNIT - III

ENERGY EFFICIENT LIGHTING:

Terminology-cosine law of illumination-types of lamps-characteristics-design of illumination systems-good lighting practice-lighting control-steps for lighting energy conservation.

UNIT - IV

ECONOMICS OF ELECTRICAL ENERGY GENERATION:

Definitions-connected load, maximum demand-demand factor-curve-base load and peck load.

UNIT - V

ECONOMICS OF ELECTRICAL ENERGY DISTRIBUTION:

Electrical load analysis-type of consumers& tariffs-line losses-corner losses-types of distribution systems- Kevin's law-loss load factor.

ECONOMICS OF ELECTRICAL DRIVES:

Selection of motors-types of loads-energy consumption during starting of ac and dc motors-braking of motors-plugging-regenerative braking.

BOOKS:

1. Electrical Machinery: Fitzerland, Kingsley, Kusko-MC Graw Hill Ltd.
2. Energy-Efficient Electrical motors: John C.Andreas-Marcel Decker Inc.
3. Electrical Technology: Edward Hughes-ElLBS.

Energy Management and good lighting practice: Fuel Efficiency Booklet 12-eeo.

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

II- SEMESTER **L P C**
4 - 4

DESIGN OF WIND ENERGY SYSTEMS

(15D32204)

UNIT-I

Historical developments, latest developments, state of art of wind energy technology, turbine rating, cost of energy, wind power plant economics, installation and operation costs, decommissioning, Indian scenario and worldwide developments, present status and future trends

UNIT-II

Nature of atmospheric winds; wind resource characteristics and assessment; anemometry; wind statistics; speed frequency distribution, effect of height, wind rose, Weibull distribution, atmospheric turbulence, gust wind speed, effect of topography.

UNIT-III

Design of wind turbine blade; effect of stall and blade pitch on coefficient of power vs tip speed ratio and cut-out wind speeds, blade materials, design characteristics, multiple stream tube theory, vortex wake structure; tip losses; rotational sampling, wind turbine design programs, aerodynamic loads, tower shadow, wind shear, blade coning, gyroscopic, transient and extreme loads.

UNIT-IV

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. Power electronics Converter and Inverter interfaces for wind energy utilization system for isolated and grid connected system.

UNIT-V

Wind farm electrical design, Planning of wind farms, special application for developing countries, maintenance and operation, wind farm management, site selection. Environmental assessment; noise, visual impact etc. Instrumentation, data loggers, remote monitoring and control.

REFERENCES:

1. Paul Gipe, Wind Energy Comes of Age, John Wiley & Sons Inc.
2. Ahmed: Wind Energy Theory and Practice, PHI, Eastern Economy Edition, 2012
3. L.L. Freris, Wind Energy Conversion System, Printice Hall.
4. Tony Burton et al, Wind energy Hand Book, John Wiley & Sons Inc.
5. Directory, Indian Wind Power 2004, CECL, Bhopal.

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2015-16

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

II- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

OPTIMIZATION OF ENGINEERING DESIGN (Elective – III)

(15D32205)

UNIT I

SINGLE VARIABLE NON-LINEAR UNCONSTRAINED OPTIMITION:

One dimensional Optimization methods:- Uni-modal function, elimination method, Fibonacci method, golden section method, interpolation methods- quadratic & cubic interpolation methods.

UNIT II

Multi variable non-linear unconstrained optimization: Direct search method – Univariant Method – pattern search methods – Powell's – Hook – Jeeves, Rosenbrock search methods – gradient methods, gradient of function, steepest decent method, Fletcher reeves method. **Variable** metric method.

UNIT III

GEOMETRIC PROGRAMMING:

Polynomials – arithmetic – geometric inequality – unconstrained G.P – constrained G.P

DYNAMIC PROGRAMMING:

Multistage decision process, principles of optimality, examples, conversion of final problem to an initial value problem, application of dynamic programming, production inventory. Allocation, scheduling replacement.

UNIT IV

Linear programming – formulation – Sensivity analysis. Change in the constrints, cost coefficients , coefficients of the constraints, addition and deletion of variable, constraints.

Simulation – Introduction – Types – Steps – application – inventory – queuing – thermal system.

UNIT V

Integer Programming – introduction – formulation – Gomory cutting plane algorithm – Zero or one algorithm, branch and bound method.

STOCHASTIC PROGRAMMING:

Basic concepts of probability theory, random variables – distributions – mean, variance, Correlation, co variance, joint probability distribution – stochastic linear, dynamic programming.

REFERENCES:

1. Optimization theory & Applications/ S.S Rao/ New Age International
2. Introductory to operation research/Kasan & Kumar/Springar
3. Optimization Techniques theory and practice / M.C Joshi, K.M Moudgalya/ Narosa Publications.
4. S.D Sharma/Operations Research
5. Operation Research/H.A. Taha/TMH
6. Optimization in operations research/R.L Rardin
7. Optimization Techniques/Benugundu & Chandraputla/Person Asia.

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING
M.Tech : ENERGY SYSTEMS

II- SEMESTER **L P C**
4 - 4

REFRACTORY SYSTEMS (Elective – III)

(15D32206)

UNIT-I

INTRODUCTION

Definition – Survey of Refractories and their Uses – Layout of a refractory plant – Classification of Refractories – Fundamental Properties of Refractories namely Physical, Thermal, Mechanical, Chemical and Electrical Properties.

UNIT-II

ALUMINO SILICATE REFRACTORIES

Silica – Raw materials – Manufacturing Steps – Properties – Applications.

Al_2O_3 – SiO_2 Phase diagram – Types of Raw materials – Types of Alumino-Silicate Refractories – Manufacturing Steps – Properties – Applications.

UNIT-III

BASIC REFRACTORIES

Raw materials, Manufacturing Steps, Properties and Applications of Forsterite, Dolomite Magnesite, Magnesia Carbon, and Chrome based refractories.

UNIT-IV

SPECIAL REFRACTORIES AND MONOLITHICS

Carbide based, Nitride based, Zirconia, Thoria, Beryllia Refractories – Raw materials, Manufacturing Steps, Properties and Applications. Fused cast refractories – Ceramic Fibers. Types of Castables – Ramming Mass – Gunning Mixes.

UNIT-V

APPLICATIONS OF REFRACTORIES

Refractories for coke oven, blast furnace, open hearth furnace, LD converter, THF, EAF, IF, Ladle furnace, slide plate system, nozzle, shroud, continuous casting; Monolithic Applications – gunning technique; Refractory, slag and metal interactions.

BOOKS FOR REFERENCE

1. D.N.Nandi, Handbook of Refractories, Tata McGraw Hill Publishing Co, New Delhi, 1991.
2. Chesters J.H, Refractroies: Production & Properties, Iron & Steel Institute, London, 1973.
3. Chester, J.H., Steel Plant Refractories, Second Edition., 1973, The United Steel Companies Ltd., Sheffield, UK.
4. Chester, J.H. Refractories, Production and Properties, 1973, Iron and Steel Institute, London.
5. Robert E.Fisher, Advances in Refractory Technology, Ceramic Transaction, Vol.4, 1990, American Ceramic Society, Westerville,Ohio, USA.
6. Handbook of Monolithics, 1980, Plibrico, Japan.
7. Modern Refractories Practice, 1961, Harbison Walker Comp., Pittsburgh.

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

II- SEMESTER **L P C**

4 - 4

SOLAR REFRIGERATION & AIR CONDITIONING *(Elective III)*
(15D32207)

UNIT - I

Review of Psychometric and (Air-conditioning) cooling load calculations-outline of Vapour Compression Refrigeration Systems – Cycle on p-h and T-o charts – C.O.P – Simple problems using property tables.

UNIT - II

Principle of working of working of vapour Absorption Refrigeration, steam jet refrigeration, thermoelectric refrigeration – classification of refrigerants – Desirable properties of ideal refrigerant - Properties of solvent - Solvent refrigerant combination properties.

UNIT - III

Solar cooling systems: vapour compression systems, Rankine cycle, Striling cycle, using P.V.Modules. Solar operated vapour absorption systems – vapour jet refrigeration systems.

UNIT - IV

Solar thermal energy storage - Active and passive systems TROMBE wall – equivalent thermal circuit - Solar green houses.

Solar cooling and dehumidification: Desiccant cooling - Solid and liquid desiccants - improving desiccant cycles - hybrid systems.

UNIT - V

Non –mechanical systems - Australian Rock system – Solar assisted Heat Pump – Economics of solar cooling systems.

Simulation of solar thermal systems - Salient features of DYNSYS, TRNSYS – model formulation – flow diagram of cooling systems.

REFERENCE BOOKS:

1. A course in Refrigeration & Air –conditioning, S.Domakundwar & S.C.Arora
2. Principles of Solar engineering, F.Kreith &J.F.Kreider, Mc Graw Hill Book company
3. Solar Cooling & Heating Volumes, I,II,III., T.Negat Vezirogulu
4. Entrepreneurship Development in New & Renewable Energy Technologies APPC & IREDA

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING
Common to M.Tech – PRODUCT DESIGN & ENERGY SYSTEMS

II- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

PRODUCT PLANNING AND MARKETING (Elective-III)
(15D32208)

UNIT-I

Classification of New Products: New products success and failure. Definition of success and failure, the latent Factors Behind the Marketing Success of New Products, Failure of New product, Factors Influencing Failure, Failures preventing new product Failure, New Product Development process and models, Model 1-The Cyclical Approach, Model 11-New product process Management

Concept Development and Statistical Tools Used : Introduction Common Sources for Product Ideas, Concept Development Methods, Idea Screening, idea Screening Approaches, Concept Testing, Definition, Methodology of Data Collection for Concept Testing, Data Analysis Techniques for Concept Testing, Concept Screen Test Method, Weighted Scoring Method, Concept Screening Matrix

UNIT-II

Diffusion of Innovation and Adoption Process : Introduction, Adoption Process, Five Stage Process, Time of Adoption, Characteristics of Adopters, Characteristics Affecting Adoption Rate, Diffusion of Innovation, Product Life Cycle Introduction, Basics of PLC, 3 Types of PLCs, Identification of Stages in a PLCSigma Method of Tracing the Product Life Cycle and Stages Identification.,

Product Mix : Introduction, Width, Length, Depth, And Consistency of Product mix, Product Lines, Product Strategies, Introduction, Types of Naming, Problem Faced due to Linguistic Differences, Branding Naming Strategies, Brand Naming Strategies, The Naming Process, The Dos and Don'ts While Naming Brands, Brand Names, Generalization.

UNIT-III

Test Marketing: Introduction, Objectives of Test Marketing-What to look for?, Pros and Cons of test Marketing, Decision Variables for Test Markets, Test Marketing Approaches, Types of Test Marketing Producers, Statistical Models for Analyzing Test Market Data, Data Project Method, Product Launch and Commercialization, The Product Launch Cycle, The Launch Mix, Issues in Launch, The Product Launch Process, Effective Plan for Product Launch, Product Launch Mistakes

Brand Identity: Introduction, What Identity is not ? Dimensions and Identity, Inner and Outer Identity, The Six Sided Prism, How to find Identity? Multiple Identities, Conclusion, Brand Image, Brand Images of Some of the Indian Brands, Techniques Used for Identifying the Brand Image, Brand Networking Techniques, Focus Groups, Constructive Techniques, Factor Analysis.

UNIT-IV

Brand Personality: Introduction, Tools to Build/Understand Brand Personality, Brand personality Scale, Three Models to Build Brand Personality, Building Brand Personality Via the 4P's and Packaging, Building Brand Personality Bottom-up. Brand Positing and Repositioning Introduction, Grabbing the Mind Space, Positioning Statement, Determine the Positioning, The MDS Way, Image and Profile Analysis, Positioning through Correspondence Analysis, By factor Analysis, Positioning Analysis, by Discriminate Mapping, Repositioning, Brand Loyalty, Definition, Brand Loyalty Measurement Models, Preference Behavior Model, Purchase Probability Model, Brand Loyalty Analysis with Markov Chains, Strategies to Build Brand Loyalty, Building Loyalty Through Strategic Differentiation

UNIT-V

Line Extension: Introduction, Why Line Extension is so hard to resist ? A Good Marketing Strategy, Extension, Measuring the Line Extension Success Brand Extension Introduction, Asker and Keller's Success Factors, Internal and External Factors Affecting Firm, Inter Brand Success Factors, Sequential Introduction of Brand Extension, Process of Brand Extension, Brand Harvesting Introduction, Types of Harvesting, Activities Adopted during Harvesting Strategy, Planning the Harvesting Strategy Implementation.

TEXT BOOKS :

1. Gien L. Urban. John R. Hauser – "Design and Marketing of new products"
2. William L. Moore&Edgar – "Product Planning and Management", A. Pessemier AGILE MANUFACTURIN
3. Dr.C. Anandan "Product Management". Tata Mc Graw Hill Education Pvt. Ltd.,
4. Philip Kotler. "Marketing Management " Person Eduction Pvt Ltd.,
5. Dr. Venu Gopal Rao. "Product and Brand Management" Himalaya Publications.

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2015-16

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING
M.Tech : ENERGY SYSTEMS

II- SEMESTER **L P C**
4 - 4

CONCURRENT ENGINEERING (Elective IV)
(15D32209)

UNIT-I

Introduction-Extensive definition of CE, CE design methodologies-Organising for CE- CE Tool box Collaborative product development

Use of Information Technology: IT Support- Solid Modelling-Product Data management-Collaborative product commerce.

UNIT-II

Artificial Intelligence- Expert Systems-Software hardware co-design

Design Stage: Life cycle design of products- opportunity for manufacturing enterprises-modality of concurrent engineering design.

UNIT-III

Automated analysis idealization control- concurrent engineering in optimal structural design-real time constraints

Manufacturing competitiveness- Checking the design process-conceptual design process mechanism –Qualitative, physical approach – an intelligent design for manufacturing for manufacturing system

UNIT-IV

JIT system- low inventory- Modular- Modelling and reasoning for computer based assembly planning-Design of automated manufacturing

Project Management Life Cycle Semi Realisation- Design for Economics- Evaluation of design for manufacturing cost

UNIT-V

Concurrent Mechanical design- Decomposition in concurrent Design-Negotiation in Concurrent Engineering Design studies – Product Realisation Taxonomy –Plan for project management on new product development- bottle neck technology development.

TEXT BOOKS:

1. Anderson M M and Hein, L Berlin, Springer Verlog-“**Integrated Product Development”**
2. Cleetus J Concurrent research Centre, Morgan Town-“**Design for Concurrent Engineering”**

JNTUACEA **R15**

2015-16

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING

Common to M.Tech (ENERGY SYSTEMS & PRODUCTION DESIGN)

II- SEMESTER	**L**	**P**	**C**
	4	**-**	**4**

REVERSE ENGINEERING (Elective-IV)
(15D32210)

UNIT I INTRODUCTION
Scope and tasks of RE - Domain analysis- process of duplicating

UNIT II TOOLS FOR RE
Functionality- dimensional- developing technical data - digitizing techniques - construction of surface model - solid-part material- characteristics evaluation -software and application- prototyping - verification

UNIT III CONCEPTS
History of Reverse Engineering – Preserving and preparation for the four stage process – Evaluation and Verification- Technical Data Generation, Data Verification, Project Implementation

UNIT IV DATA MANAGEMENT
Data reverse engineering – Three data Reverse engineering strategies – Definition – organization data issues - Software application – Finding reusable software components – Recycling real-time embedded software – Design experiments to evaluate a Reverse Engineering tool – Rule based detection for reverse Engineering user interfaces – Reverse Engineering of assembly programs: A model based approach and its logical basics

UNIT V INTEGRATION
Cognitive approach to program understated – Integrating formal and structured methods in reverse engineering – Integrating reverse engineering, reuse and specification tool environments to reverse engineering -–coordinate measurement – feature capturing – surface and solid members

REFERENCES

1. Design Recovery for Maintenance and Reuse, T J Biggerstaff, IEEE Corpn. July 1991
2. White paper on RE, S. Rugaban, Technical Report, Georgia Instt. of Technology, 1994
3. Reverse Engineering, Katheryn, A. Ingle, McGraw-Hill, 1994
4. Data Reverse Engineering, Aiken, Peter, McGraw-Hill, 1996
5. Reverse Engineering, Linda Wills, Kluiver Academic Publishers, 1996
6. Co-ordinate Measurment and reverse engineering, Donald R. Honsa, ISBN 1555897, American Gear Manufacturers Association

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JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

II- SEMESTER **L P C**
4 - 4

ENERGY RESOURCES (Elective IV)
(15D32211)

UNIT I COMMERCIAL ENERGY
Coal, Oil, Natural Gas, Nuclear power and Hydro - their utilization pattern in the past, present and future projections of consumption pattern - Sector-wise energy consumption – environmental impact of fossil fuels – Energy scenario in India – Growth of energy sector and its planning in India.

UNIT II SOLAR ENERGY
Solar radiation at the earth's surface – solar radiation measurements – estimation of average solar radiation - solar thermal flat plate collectors - concentrating collectors – solar thermal applications - heating, cooling, desalination, drying, cooking, etc – solar thermal electric power plant - principle of photovoltaic conversion of solar energy, types of solar cells - Photovoltaic applications: battery charger, domestic lighting, street lighting, water pumping etc - solar PV power plant – Net metering concept.

UNIT III WIND ENERGY
Nature of the wind – power in the wind – factors influencing wind – wind data and energy estimation - wind speed monitoring - wind resource assessment - Betz limit - site selection - wind energy conversion devices - classification, characteristics, applications – offshore wind energy – Hybrid systems - safety and environmental aspects – wind energy potential and installation in India - Repowering concept.

UNIT IV BIO-ENERGY
Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - direct combustion – biomass gasification - pyrolysis and liquefaction – biochemical conversion - anaerobic digestion - types of biogas Plants - applications - alcohol production from biomass – bio diesel production – Urban waste to energy conversion - Biomass energy programme in India.

UNIT V OTHER TYPES OF ENERGY
Ocean energy resources - principle of ocean thermal energy conversion (OTEC) - ocean thermal power plants - ocean wave energy conversion - tidal energy conversion – small hydro – geothermal energy - geothermal power plants – hydrogen production and storage - Fuel cell – principle of working - various types - construction and applications.

REFERENCES
1. Sukhatme, S.P., Solar Energy, Tata McGraw Hill, 1984.
2. Twidell, J.W. and Weir, A., Renewable Energy Sources, EFN Spon Ltd., 1986.
3. Kishore VVN, Renewable Energy Engineering and Technology, Teri Press, New Delhi, 2012
4. Peter Gevorkian, Sustainable Energy Systems Engineering, McGraw Hill,2007
5. Kreith, F and Kreider, J. F., Principles of Solar Engineering, McGraw-Hill, 1978.
6. Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, Oxford University Press, U.K, 1996

2015-16

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING
M.Tech: ENERGY SYSTEMS

II- SEMESTER **L P C**
4 - 4

MAINTENANCE ENGINEERING AND MANAGEMENT (Elective IV)
(15D32212)

UNIT-I:

Maintenance engineering objectives-Basic principles and approaches-Types of maintenance-Specifications and functions-Systems approach-performance indices-planning and control-Strategy.

UNIT-II:

Maintenance management and control-functions and organization-critical maintenance-effective elements-project control methods-control indices - Maintainability-Concepts-tasks-modeling and allocation-prediction-FMECA-reliability and maintainability trade off-Design for maintainability-design methods. .

UNIT-III:

Preventive maintenance-elements and principle-measures-mathematical models-Advantages and disadvantages - Corrective maintenance-types-measures-mathematical models-effective failure rate equations - Reliability Centered Maintenance-goals and principles-components-predictive testing and Inspection techniques-effective measurement indicators-Advantages.

UNIT-IV:

Quality in Maintenance-Processes-Control Charts-Post maintenance testing-Maintenance Safety-maintenance tasks-improving safety-personnel safety.

UNIT-V:

Maintenance costing-factors-budget type and approaches-labor cost estimation-material cost estimation-cost estimation model-cost related indices-economic analysis-Convex and Concave costs-profit and life cycle cost tradeoffs.

REFERENCS BOOKS:

1. A. K. Gupta, Reliability, Maintenance and Safety Engineering,
2. B. S. Dhillon, Engineering Maintenance A Modern Approach, CRC Press.
3. Charles E. Ebeling, Reliability and Maintainability Engineering, Tata McGraw Hill, 2000.

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2015-16

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS): ANANTAPURAMU
DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech : ENERGY SYSTEMS

II- SEMESTER

L	P	C
0	4	2

ENERGY OPERATIONS LAB
(15D32213)

List of Experiments

S.No.	Experiment Name
1	Estimation of Load & Solar Panel Requirement for an house hold
2	Study of plant location of wind mills
3	Calculation of payback period for domestic solar water heater – A case study
4	Industrial visit of mind mills
5	Study on captive power generation of an industry
6	Study of Energy efficient building
7	Estimation of drag force by using wind tunnel
8	Estimation of lift force by using wind tunnel

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Course Structure of R21 Academic Regulations for M.Tech (Regular) Programs with effect from AY 2021-2022

DEPARTMENT OF MECHANICAL ENGINEERING

ENERGY SYSTEMS

I SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	21D31103	Conduction and Radiation Heat Transfer	PC	3	0	0	3
2	21D32101	Renewable Energy Sources	PC	3	0	0	3
3	**Professional Elective – I**						
	21D32102	Energy Management	PE	3	0	0	3
	21D32103	Direct Energy Conversion Systems					
	21D32104	Applied Solar Energy Engineering					
4	**Professional Elective – II**						
	21D32105	Reliability & Safety Engineering	PE	3	0	0	3
	21D32106	Data Acquisition and Processing System					
	21D32107	Design of Heat Transfer Equipment					
5	21D11109	Research Methodology and IPR	MC	2	0	0	2
6	21D11110	English for Research Paper Writing	AC	2	0	0	0
	21D11111	Value Education					
	21D11112	Pedagogy Studies					
7	21D32108	Energy Utilization Lab	PC	0	0	4	2
8	21D32109	Thermal Energy Lab	PC	0	0	4	2
Total				**16**	**00**	**08**	**18**

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Course Structure of R21 Academic Regulations for M.Tech (Regular) Programs with effect from AY 2021-2022

DEPARTMENT OF MECHANICAL ENGINEERING

ENERGY SYSTEMS

II SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	21D32201	Energy Conservation and Audit	PC	3	0	0	3
2	21D32202	Energy Efficient Electrical Systems	PC	3	0	0	3
3	**Professional Elective – III**						
	21D32203	Waste Heat Recovery Systems	PE	3	0	0	3
	21D32204	Total Quality Management					
	21D32205	Solar Refrigeration & Air Conditioning					
4	**Professional Elective – IV**						
	21D32206	Design of Wind Energy Systems	PE	3	0	0	3
	21D32207	Energy Resources					
	21D32208	Optimization of Engineering Design					
5	21D11209	Technical Seminar	PR	0	0	4	2
6	21D11210	Disaster Management	AC	2	0	0	0
	21D11211	Constitution of India					
	21D11212	Stress Management by Yoga					
7	21D32209	Energy Operations Lab	PC	0	0	4	2
8	21D32210	Renewable Energy Systems Laboratory	PC	0	0	4	2
Total				**14**	**00**	**12**	**18**

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Course Structure of R21 Academic Regulations for M.Tech (Regular) Programs with effect from AY 2021-2022

DEPARTMENT OF MECHANICAL ENGINEERING

ENERGY SYSTEMS

III SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	**Professional Elective – V**						
	21D32301	Energy Ecology & Environment	PE	3	0	0	3
	21D32302	Product Planning and Marketing					
	21D32303	Rapid Prototyping Technologies					
2	**Open Elective**						
	21D30301	Mechatronics	OE	3	0	0	3
3	21D32304	Dissertation Phase – I	PR	0	0	20	10
4	21D00301	Co-Curricular Activities	PR				2
Total				**06**	**00**	**20**	**18**

IV SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	21D32401	Dissertation Phase – II	PR	0	0	32	16
Total				**00**	**00**	**32**	**16**

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code	21D31103	CONDUCTION AND RADIATION HEAT TRANSFER (21D31103)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives:

1. To understand three modes of heat transfer.
2. To understand Conduction through spherical shells.
3. To know Heating and cooling of bodies with negligible internal resistance.
4. To gain knowledge about thermal radiation.
5. To understand Radiation network for an absorbing and transmitting medium.

Course Outcomes (CO): Student will be able to

1. Tackle 2D heat transfer problems by applying appropriate governing equations and boundary conditions.
2. Apply suitable methods to solve various Conduction formulations.
3. Setup basic techniques to understand and analyze physical systems.
4. Examine several means and assumptions for analyze radiation heat transfer problems.
5. Use acquired knowledge to develop systems suitable for Industrial applications.

UNIT – I		Lecture Hrs:10

CONDUCTION : Introduction of three modes of heat transfer, steady, unsteady state heat transfer process, governing equations and boundary conditions
Two dimensional steady state conduction, semi-infinite and finite flat plate; temperature field in infinite and finite cylinders.

UNIT – II		Lecture Hrs:10

Conduction through spherical shells. Numerical method: finite difference method - simple problems.

UNIT – III		Lecture Hrs:10

Heating and cooling of bodies with negligible internal resistance, sudden changes in the surface temperature of infinite plates, cylinders and semi-infinite bodies-simple problems.

UNIT – IV		Lecture Hrs:10

RADIATION :
Review of the thermal radiation - gas radiation, mean beam length exchange between gas volume and black enclosure, heat exchange between gas volume and gray enclosure, problems.

UNIT – V		Lecture Hrs:10

Radiation network for an absorbing and transmitting medium, radiation exchange with specular surfaces, radiation exchange with transmissivity and reflecting absorbing medium. Formulation for numerical solution.
Solar radiation: Radiation properties of environment, effect of radiation on temperature measurement, the radiation heat transfer coefficient, problems.

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Textbooks:
1) Heat transfer -J.P. Holman, International Student Edition, TMH. 2) Heat Transfer -Gibhart - Mc. Graw Hill. 3) Conduction Heat Transfer- -Schneider Addison -Wiesthly 4) Conduction of Heat in Solids -Carslaw& Jaeger, ASME
Reference Books:
1) Fundamentals of Heat and Mass Transfer -R.C. Sachdev New Age International 2) Heat and Mass Transfer by R. K. Rajput, S.Chand Technical Publishers
Online Learning Resources:
https://nptel.ac.in/courses/112/105/112105271/

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code	21D32101	RENEWABLE ENERGY SOURCES (21D32101)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives:

1. To provide a survey of the most important renewable energy resources.
2. The technologies for harnessing these resources within the framework of a broad range of simple to state- of -the-art energy systems.
3. To provide wind mills and wind turbine systems
4. To understand ocean thermal energy sources, Ocean thermal energy power plant development.
5. Knowledge on Fuel cell energy and Biomass energy.

Course Outcomes (CO): Student will be able to

1. Demonstrate the generation of electricity from various Non-Conventional sources of energy, have a working knowledge on types of fuel cells.
2. Estimate the solar energy, Utilization of it, Principles involved in solar energy collection and conversion of it to electricity generation.
3. Explore the concepts involved in wind energy conversion system by studying its components, types and performance.
4. Illustrate ocean energy and explain the operational methods of their utilization.
5. Acquire the knowledge on Geothermal energy.

UNIT - I		Lecture Hrs:10

Availability of solar energy, Measurement of sunshine, solar radiation data, estimation of average solar radiation, the black body, absorptance and emittance, Kirchoff's law. Reflection from surfaces, Solar energy selection, selective surfaces, Construction of solar flat plate and evacuated tube collectors, Performance of solar energy collectors, Solar heating and cooling.

UNIT - II		Lecture Hrs:8

Wind mills and wind turbine systems, Classification of wind machines: Horizontal & Vertical axis configuration. High and low solidity rotors, Elements of wind mills and wind turbine systems, Aerodynamic models, RankineFroud Actuator disc model, Betz limit, angular momentum wake rotation theory, Aerofoil sections and their characteristics, Estimation of power output and energy production.

UNIT - III		Lecture Hrs:10

OCEAN THERMAL ENERGY:
Ocean thermal energy sources, Ocean thermal energy power plant development, Closed and open cycles. Advantages and operating difficulties.
TIDAL & WAVE ENERGY
Tidal power sources, Conventional and latest design of tidal power system, The ocean wave, Oscillating water column (Japanese) and the Dam, Atol design.

UNIT - IV		Lecture Hrs:10

GEOTHERMAL ENERGY :

Earth as source of heat energy, stored heat and renewability of earth's heat, Nature and occurrence of geo thermal field, Classification of thermal fields, Model of Hyper thermal fields & Semi thermal fields, drilling hot water measurements.

UNIT - V		Lecture Hrs: 12

FUEL CELL ENERGY:

Description, properties and operation of fuel cells, Major components & general characteristics of fuel cells, Indirect methanol fuel cell systems. Phosphoric acid fuel cell systems and molten carbonate fuel cell systems.

BIOMASS ENERGY:

Types of conversion techniques for the production of solid, liquid and gaseous fuels by chemical and biochemical methods, and Biomass gasifiers- Selection of a model and size, Technical, Climatic, geographical and economic issues.

TEXTBOOKS:

1. Principles of Solar Engineering: F.Kreith&J.F.Krieder/Mc.Graw Hill Book Co
2. Wind Energy conversion Systems: L.C.Freris, Prentice Hall, Inc..
3. Non-conventionalEnergy Sources: G.D. Rai
4. Energy Technology: S. Rao& B.B. Parulekar
5. Geo thermal energy: H.Christopher&H.Armstead.
6. Photo Voltaic Energy Systems, Design&Applications: Mathew Buresch, McGraw Hill Book Co..

REFERENCE BOOKS :

1. Bio Gas Technology, A Practical Hand Book: K.C.Khendelwal&S.S.MahdiMcGraw Hill Book Co..
2. Hand Book of Batteries and Fuel cells: David Linden, McGraw Hill Book Co..
3. Energy Conversion Systems: H.A.Sorenson: John Wiely&S.jons
4. Renewable Energy Sources & Conversion technology: Bansal.K: Leemann&Meliss
5. Energy technology Hand Book: EdD.M.Considine
6. Principles of energy conversion AW.Culp

Online Learning Resources:

https://onlinecourses.nptel.ac.in/noc21_ch11/preview

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code	21D32102	ENERGY MANAGEMENT (21D32102) PE – I	L	T	P	C
Semester	I		3	0	0	3

Course Objectives: To impart knowledge on

1.Energy auditing in engineering and process industry.
2. Physical depreciation-Functional depreciation
3. Methods of investment appraisal
4. Necessary steps of energy management programmer
5. level of power generation

Course Outcomes (CO): Student will be able to

1. Apply the principles energy management for conservation.
2. Describe the energy rate structures.
3. Examine the economic evaluation of energy conservation solutions.
4. Role and qualities of project manager
5. Energy transformation & distribution & energy self sufficiency

UNIT - I		Lecture Hrs:10

ENGINEERING ECONOMICS:
Managerial objectives - steps in planning- Capital budgeting- Classification of costs- Interest- Types- Nominal and effective interest rates Discrete and continuous compounding - discounting - Time value of money - Cash flow diagrams - Present worth factor, Capital recovery factor, Equal annual payments - Equivalence between cash flows.

UNIT - II		Lecture Hrs:8

DEPRECIATION & COST ANALYSIS:
Aims-Physical depreciation-Functional depreciation- Methods of depreciation-Straight line method, Declining balance method, Sum of years digits method, Sinking fund method, Service output method- Capital recovery with return-Service life estimation- Morality curves. Break even analysis and break even chart- Minimum cost analysis- Benefit cost analysis- Life cycle cost analysis.

UNIT - III		Lecture Hrs:10

PROJECT MANAGEMENT:
Methods of investment appraisal- Rate of return method, Payback period method, Net present value method (NPV)- Internal Rate of Return method(IRR)- Adoption of the methods in energy conservation campaign- Types of projects- Purpose of project management - Classification – Role and qualities of project manager - Types of budgets - Budget committee – budgeting.

UNIT - IV		Lecture Hrs:10

ENERGY MANAGEMENT PROGRAMS:
Necessary steps of energy management programmer - Concepts of Energy management - General principles of energy management – Energy management in manufacturing and process industries- Qualities and functions of Energy manager - Language of Energy manager-Checklist for top management.

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

UNIT - V		Lecture Hrs: 12

ENERGY POLICY, SUPPLY, TRADE& PRICES:
Energy resources in India – level of power generation – transmission & distribution of power. Indian energy policy,Energy trade & its economic impacts – domestic energy production – Energy transformation & distribution & energy self-sufficiency. International & National crude oil prices – domestic fuel prices – natural gas, LPG, kerosene and firewood - pricing policy.

TEXTBOOKS:

1. Albert Thumann, Handbook of Energy Audits, The Fairmont Press Inc., Atlanta gergia, 1979.
2. Murphy W.R and Mckay G, Energy Management, Butterworths, London, 1982.
3. Albert Thumann, Plant Engineer and Management guide to Energy Conservation, Van Nost and Reinhold Co., Newyork.
4. Energy Audits, E.E.O.-Book-lets, U.K. 1988.

REFERENCE BOOKS :

1. Craig B.Smith, “Energy Management Principles”, Pergamon Press.
2. The role of Energy Manager, E.E.O., U.K.
3. The Energy conservation Design Resource Hand Book-The Royal architectural Institute of Canada.
4. Energy Management Hand Book-Ed. By Wayne C. Turner, John Wiley and sons, 1982.

Online Learning Resources:

https://www.ametuniv.ac.in/naac/C6/6_3/634/Professional_Development_Programme_attended.pdf

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code	21D32103	DIRECT ENERGY CONVERSION SYSTEMS (21D32103)	L	T	P	C
Semester	I	PE – I	3	0	0	3

Course Objectives:

1. Understand the concepts of Planck's black-body radiation distribution from different black body
2. Understand Manufacturing processes (wafer and cell) of single crystal
3. To provide Design requirements of PV modules.
4. Understand key concepts of energy conversion in solar cells
5. Understand the various approaches used to generation of hydrogen

Course Outcomes (CO): Student will be able to

1. Spectral distribution of extra-terrestrial radiation
2. Absorption coefficient and reflectance
3. Design requirements of PV modules
4. Stand alone and grid connected and load estimation.
5. Transport and storage of hydrogen: physical, chemical &Fuel Cells.

UNIT - I		Lecture Hrs:10

Energy Balance of the earth – The Greenhouse effect – Physical Source of sunlight – Planck's black-body radiation distribution from different black body temperatures – The earth and Solar Constant – Spectral distribution of extra-terrestrial radiation – Basic earth-sun angles – Solar time and equation of time – attenuation of solar radiation by the atmosphere – Direct and diffuse radiation at the ground – Empirical equations for predicting the availability of solar radiation.

UNIT - II		Lecture Hrs:8

Photovoltaics (PV): Semiconductor physics and Operating principle – Silicon as PV material - Direct and indirect band-gap material – Flow of Silicon material – Single crystal Silicon Solar cell – Structure – Important electrical parameters – Ideal and approximate equivalent circuits - Manufacturing processes (wafer and cell) of single crystal, multi-crystalline and Edge Defined Film Fed Growth Silicon - Temperature and Irradiation effects – Absorption coefficient and reflectance - Silicon film, Cadmium telluride (cdTe), Copper Indium Gallium Diselenide, amorphous silicon – Comparison of 'Thin film' and 'Bulk crystal' technology – manufacturing (module making) processes of amorphous silicon on glass, stainless steel and plastic substrates – Typical materials used - Concentrator technology and the importance of tracking – Comparison of efficiencies of various technologies – Recent trends in PV technology and manufacturing

UNIT - III		Lecture Hrs:10

PV modules and Arrays – Design requirements of PV modules – Rating of PV modules – Standard Test Conditions (STC), Normal Operating Cell Temperature (NOCT) and Standard Operating Conditions (SOC) – Output curves ('Current-Voltage' or 'I-V' and 'Power-Voltage' or 'P-V') under various irradiance and temperature conditions – Mounting structure for PV modules/arrays – Orientation and array layout – Effects of shading - Other balance of systems (BOS) and protective devices: blocking and bypass diodes, movistors – Roof mounted arrays – Building integrated PV

(BIPV) – Typical faults and diagnosis – Hot Spot problem in a PV module and safe operating area - Performance measurement of typical parameters of cells/modules under natural and simulated light – Indoor sun simulators - Outdoor PV array testers – ASTM and IEEE standards for Class A and Class B simulators – Pulsed, steady state and single flash types – Determination of temperature coefficients, series and shunt resistances, curve correction factor - Computation of efficiency and fill factor – Translation of parameters actually measured to STC – Reliability Testing: Qualification tests, IEC Standards 61215 & 61646 – Reliability test – Field stress testing

UNIT - IV		Lecture Hrs:10

PV Systems – Stand alone and grid connected – Load estimation – Daily load demand – Solar radiation/irradiance table for a particular location - Sizing of the PV array, battery, inverter and other BOS – Maximizing efficiency of sub-systems – Balance of systems – Single axis and two axis tracking at optimum inclination of the PV array – Power conditioning and control – Maximum Power Point Trackers, Charge controllers/regulators, AC/DC Converters, DC/AC inverters – Alarms, indicators and monitoring equipment – Energy Storage: Batteries, Deep cycle lead acid type, Battery Design and construction, Other types of batteries, Battery Selection criteria, Safety issues – Typical applications of PV – Hybrid systems: PV-Wind, PV-Diesel engine, PV-Mains - System Sizing examples: Domestic loads, Water pumping, Lighting (using CFLs, White LEDs) - hybrid systems, village power packs – Installation practices – Trouble shooting – Economic analysis: Life Cycle Cost analysis – Environment impacts of PV – Green buildings – Potential for GHG emission reduction of installed PV systems

UNIT - V		Lecture Hrs: 12

The Hydrogen Economy – Advantages of hydrogen as an energy carrier – Components of the hydrogen economy - Generation of hydrogen - Transport and storage of hydrogen: physical and chemical - Fuel Cells – Classification of fuel cells based on (a) Type of electrolyte (b) Type of the fuel and oxidant (c) operating temperature (d) application and (e) chemical nature of electrolyte

TEXTBOOKS:

1. Solar Electricity /Edited by Tomas Markvart/John Wiley and Sons
2. Solar Cells – Operating Principles, Technology and System Applications /Martin A. Green/Prentice Hall Inc
3. Modelling Photovoltaic Systems using P Spice/Luis Castaner and Santiago Silvestre/John Wiley and Sons
4. Solar Energy – Fundamentals and Applications/H.P. Garg and J. Prakash/Tata McGraw-Hill

REFERENCE BOOKS :

1. Generating Electricity from the Sun/Edited by Fred C. Treble/Pergamon Press
2. Amorphous Silicon Solar Cells/K.Takahashi and M.Konagai/North Oxford Academic
3. Photovoltaic Systems Engineering/Roger Messenger/CRC Press
4. Fuel Cells/LivinOniciu/Abacus Press 1976

Online Learning Resources:

https://sciresol.s3.us-east-2.amazonaws.com/IJST/Articles/2016/Issue-43/Article8.pdf

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code	21D32104	APPLIED SOLAR ENERGY ENGINEERING (21D32104)	L	T	P	C
Semester	I	PE – I	3	0	0	3

Course Objectives:

1. To explain the concept of various forms of solar energy
2. To outline division aspects and utilization of solar energy sources for both domestics and industrial applications.
3. To understand the various Solar cell fundamentals.
4. To knowledge on discounted Cash Flow
5. To design aspects, thermo-chemical reactor.

Course Outcomes (CO): Student will be able to

1. Knowledge in working principle of various solar energy systems
2. Capability to do basic design of solar energy systems
3. Awareness on various Role of Nano-Technology
4. coasting of solar system
5. Still, timber drying, crop drying, cooker

UNIT - I		Lecture Hrs:10

SOLAR RADIATION:

Sources of radiation –sun earth relationship, Solar Time and angles, day length, angle of incidence on tilted surface; Sun path diagram, Solar Radiation: Extraterrestrial Radiation; Effect of earth atmosphere; Estimation of solar radiation on horizontal and tilted surfaces.
Geographic Distribution of solar radiation, Phyrellio, pyranometer, equation of time-estimation of average radiation falling on tilled.

UNIT - II		Lecture Hrs:8

SOLAR ENERGY TECHNOLOGIES:

Performance analysis of a liquid Flat-plate collector, Total loss coefficient and heat losses: Top loss coefficient, Bottom loss coefficient, Side loss coefficient. Solar concentrating collectors, types of concentrating collectors, Parabolic Dish System, The central power tower system, The Parabolic Trough System, Tracking CPC and Solar Swing, Performance analysis of cylindrical parabolic collector, Compound parabolic concentrator (CPC).

UNIT - III		Lecture Hrs:10

SOLAR CELLS:

Solar cell fundamentals, solar cell classification, solar cell, module, panel array construction, maximum power pint trackers(MPPT), solar PV applications, The Recent developments in Solar cells, Role of Nano-Technology in Solar cells.

UNIT - IV		Lecture Hrs:10

ECONOMICS:

Discounted Cash Flow-light cycle, coasting of solar system, production function and optimization

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

UNIT - V		Lecture Hrs:12

THERMAL POWER:
The power concepts- design aspects, thermo-chemical reactor.
SOLAR POND AND SOLAR STILLS:
Working Principle-Construction-operating difficulties and remedies, Agriculture and Domestic applications: Still, timber drying, crop drying, cooker.

TEXTBOOKS:
1. Solar Energy Thermal Process Diffice and Beckman
2. Solar Heating and Cooling by Kreith and Kreider
3. Solar Energy Utilization by G.D.Rai
4. Solar Energy Utilization by G.D.Rai ,Khanna Publishers.

REFERENCE BOOKS :
1. Renewable Energy Sources and Emerging Technologies- By D.P. Kothari, PHI Pub.,
2. Applied Solar Energy by Meinel and Meinel
3. Non-Conventional Energy Resources by B.H . Khan, Tata McGraw Hill
4. Energy Resources Utilization and Technologies By Anjaneyulu, BS Pub.,

Online Learning Resources:
https://ieeexplore.ieee.org/abstract/document/8529033

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code	21D32105	RELIABILITY & SAFETY ENGINEERING (21D32105)	L	T	P	C
Semester	I	PE – II	3	0	0	3

Course Objectives:

1. Demonstrate the approaches and techniques to assess and improve process and/or product quality and reliability.
2. Introduce the principles and techniques of Statistical Quality Control and their practical uses in product and/or process design and monitoring
3. Illustrate the basic concepts and techniques of modern reliability engineering tools.
4. To understand fault detection, non-destructive testing.
5. To understand Monitoring techniques Signature analysis-vibration and noise monitoring,

Course Outcomes (CO): Student will be able to

1. Knowledge on Elements of probability theory, probability of union and intersection of events
2. Practice Reliability of non-repairable systems, reliability network
3. Analysing Maintainability and availability,
4. Identifying Fault detection, non-destructive testing
5. Developing the Monitoring techniques Signature analysis-vibration

UNIT - I		Lecture Hrs:10

Elements of probability theory, probability of union and intersection of events, mutually exclusive events, statistical independence, random variables, PDF and CDF, binomial, Poisson and Gaussian distributions.
Component reliability-definition of reliability and hazard functions, failure distributions, exponential Weibull and gama distributions, uniform distribution, bath tub curve.

UNIT - II		Lecture Hrs:8

Reliability of non-repairable systems, reliability network, series, parallel and rout of configurations, decomposition method, cut set & tie set method, methods of improving reliability.

UNIT - III		Lecture Hrs:10

Maintainability and availability, MTBF and MTTR, probability and frequency of failure, state space analysis, Markov process, steady state probability, and dependent failures.
Failure types and causes of failure- failure classification, case studies, human factors analysis of different causes of failures.

UNIT - IV		Lecture Hrs:10

Fault detection, non-destructive testing, X-ray and Gamma ray radiography, Xerography, Electromagnetic methods, ultrasonic methods.

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UNIT - V		Lecture Hrs: 12
Monitoring techniques Signature analysis-vibration and noise monitoring, faults and vibration modes, permissible limits of vibrations, temperature monitoring, infrared camera. Wear monitoring, analysis of wear partials, ferography, spectroscopic analysis, performance trend monitoring.		
TEXTBOOKS: 1. Reliability engineering" By Balaguruswamy. 2. "Testing and inspection of materials" by H.E.Davies. 3. "Instrumentation, Measurement and analysis" by Prof.B.C.NaKra 4. "Mechanical fault diagnosis" By R.A.Collacolt.		
REFERENCE BOOKS : Maintenance Engineering Hand Book		
Online Learning Resources:		
https://onlinecourses.nptel.ac.in/noc20_mg43/preview		

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code	21D32106	DATA ACQUISITION & PROCESSING SYSTEMS (21D32106)	L	T	P	C
Semester	I	PE – II	3	0	0	3

Course Objectives:

1. To Understand the principles of transducer
2. To know the number systems: Decimal, Binary, Octal, Hexadecimal and conversion from one system to the others
3. To analyse memories &processors

Course Outcomes (CO): Student will be able to

1. Photoelectric, piezoelectric & Potentiometer transducers
2. Understand Boolean algebra
3. Design of 8085:block diagram

UNIT - I — Lecture Hrs:10

TRANSDUCERS:

Basic requirements of a transducer- principle of operation, application of strain gauges, capacitive, Inductive, Photoelectric, piezoelectric &Potentiometer transducers. Resistance thermometers, thermocouples, hermistors, photoconductive & photovoltaiccells, and Electromagnetic& Turbine type flow meters.

UNIT - II — Lecture Hrs:8

DATA REPRESENTATION:

Number systems: Decimal, Binary, Octal, Hexadecimal and conversion from one One system to the others; Logic Gates: AND, OR, NOT, NAND, NOR, EX-OR, EX-NOR gates; Logic circuit Implementation: 'Sum of products and product of sums' Boolean equations; Boolean algebra: postulates, theorems and simplification of Boolean equations; Binary arithmetic: Addition, subtraction Circuits; Digital codes: BCD, XS-3, Gray, 2421 and ASCII codes, BCD to decimal decoders; parity checkers and generators.

DIGITAL CIRCUITS

Flip Flops: R-S, JK ,D, Master-slave, Latches – Timing Diagrams – Registers, Buffer, shift and controlled shift registers- Counters-ripple, synchronous, ring and Presettable counters; Astable and monostablemultivibrators.

UNIT - III — Lecture Hrs:10

MEMORIES &PROCESSORS:

Memories: ROMs, PROMs, EPROMs and RAMs, expanding memory size; Processors: arithmetic Logic Unit, register array- control unit, memory, input/output, system concepts, hardware & software, and low-level& high-level languages.

INSTRUMENTATION SYSTEMS:

Representation of generalized data acquisition system; single and multi-channel data acquisition systems; microprocessor based data logger; microprocessor control of petrol engine.

UNIT - IV		Lecture Hrs:10

COMPUTING SYSTEMS:

Simple computing: architecture, instruction set. Fetch & execution cycles, and Microprogramming- Advanced computing- architecture, memory & reference instructions. register instructions, jump& call instruction. Arithmetic instructions, Increments/decrements & rotates, logic instructions. Arithmetic & logic immediates, jump instructions. Extended register instructions indirect instructions. -Simple programming.

INTEL 8085 MICROPROCESSOR:

The 8085:block diagram:pinout diagram. Additional instructions. minimum system and timing diagrams; I/O operations: programmed I/O, interrupt driven I/O and Direct memory access

UNIT - V		Lecture Hrs: 12

DATA CONVERSION:

Digital to analog conversion: weighted resistor; and R-2Rladder D/A converters; Analog to digital conversion: successive approximation. Single dual slope integration, and parallel conversion A/D converters, A/D converters using voltage to frequency &voltage to time conversion; sample and hold circuits; multiplexing: D/A and A/D multiplexing; de multiplexing.

TEXTBOOKS:

1. Electronic Instrumentation & Measurement Techniques: Willman David Cooper, Prentice-Hall of India pvt-ltd.,
2. Instrumentation Devices and Systems: Csrangan, OR Sharma and V.S.V Muni; Tata McGraw-Hill Publishing CO. Ltd..
3. Integrated Digital Electronics; Walter A.Triebel; Printice Hall..Iinc..

REFERENCE BOOKS :

1. Modern Digital Electronics: R.P. Jain,TataMcGraw-Hill Publishing Co., ltd..
2. Digital Computer Electronics, An Introduction To Microcomputers: Albert.Paull, Malvino;TataMcGraw-Hill Publishing Co.,Ltd.,

Online Learning Resources:

http://nitttrc.edu.in/nptel/courses/video/108105088/L07.html

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code	21D32107	DESIGN OF HEAT TRANSFER EQUIPMENT (21D32107)	L	T	P	C
Semester	I	PE – II	3	0	0	3

Course Objectives:

1.To Understand theprinciples of heat exchangers
2.To know the condensers evaporators and compressors
3. To analyse the cooling towers, ductsfans and pipe systems

Course Outcomes (CO): Student will be able to

1. Design Of Heat Exchangers, condensers evaporators, compressors, cooling towers,ducts, fans and piping systems

UNIT - I — Lecture Hrs:10

DESIGN OF HEAT EXCHANGERS:
Heat Exchangers-mean temperature differences for parallel and counter flow- effectiveness method (N.T.U)
DESIGN OF CONDENSERS:
Overall heat transfer coefficients- temperature distribution and heat flow in a condenser- pressure drop in a condenser –extended fin surfaces-consideration of fouling factor-L.M.T.D. correction factor.

UNIT - II — Lecture Hrs:8

DESIGN OF EVAPORATORS:
Temperature distribution and heat flow in an evaporator-pressure drop- factor to be consider in the design of heat transfer equipment-types of heat consideration of fouling factor –correction factor
DESIGN OF COMPRESSORS:
Types-equivalent shaft work-volumetric efficiency-factors affecting total volumetric efficiency – compound compression with inter cooling- rotary compressors-surging.

UNIT - III — Lecture Hrs:10

DESIGN OF COOLING TOWERS AND SPRAY PONDS:
Classification-performance of cooling towers – analysis of counter flow cooling towers-enthalpy-temperature diagram of air and water- cooling ponds- types of cooling ponds –cross flow cooling towers- procedure for calculation of outlet conditions.

UNIT - IV — Lecture Hrs:10

DESIGN OF DUCTS:
Continuity equation-Bernoulli's equation-pressure losses-frictional charts- coefficient of resistance for fillings- duct sizing methods.
DESIGN OF FANS:
Standard air-fan horsepower-fan efficiency-similarity laws-fan laws-performance coefficients-theoretical expression for total pressure drop by a fan-centrifugal fan- axial flow fan-system resistance.

UNIT - V		Lecture Hrs: 12
PIPING SYSTEM: Requirements of a good piping system-pressure drop in pipes-moody chart-refrigerant piping-discharge line-liquid line-suction line-piping arrangement		
TEXTBOOKS: 1. Heat and mass transfer by Arora&Domkundwar. 2. Refrigeration & Air-Conditioning by P.L.Ballaney		
REFERENCE BOOKS : 1. Refrigeration & Air-Conditioning byC.P.Arora. 2. .Refrigeration & Air-Conditioning by Stoecker		
Online Learning Resources:		
/nptel.ac.in/courses/103/107/103107207/		

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code	21D32108	ENERGY UTILIZATION LABORATORY (21D32108)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives:

1. The basic principles of Renewable and non-renewable energy sources with emphasis on their analysis and application to practical engineering problems.
2. Renewable resources include solar energy, wind, hydro, the heat of the earth (geothermal), plant materials (biomass), waves, ocean currents, temperature differences in the oceans and the energy of the tides.
3. Renewable energy technologies produce power, heat or mechanical energy by converting those resources either to electricity.

Course Outcomes (CO): Student will be able to

1. Understanding the estimation of energy saving
2. Develop the flat plate collector
3. Estimate the solar power by centrifugal pump
4. Develop the biomass plant
5. Design of solar cooker

List of Experiments

1. Survey of alternative Energy Sources
2. Estimation of energy Saving by Solar Water Heating
3. Flat-Plate Collector Requirement Calculations
4. Estimation of Discharge of Centrifugal pump using Solar Power
5. Demonstration of Wind Tunnel
6. Study of Biomass plant
7. Study of Bio-Gasifier
8. Performance of Solar Cooker
9. Study of Geothermal energy
10. Study of Tidal and wave energy

REFERENCE BOOKS :

Online Learning Resources:

https://onlinecourses.nptel.ac.in/noc21_ch11/preview

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

COURSE CODE	21D32109	THERMAL ENERGY LABORATORY (21D32109)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives:

1.To understand the heat pipe
2. To estimate the heat transfer rate
3. To estimate the cop from solar refrigeration system
4. Knowledge on solar collectors
5. To study the energy audit

Course Outcomes (CO): Student will be able to

1.Create the heat pipe for heat flow
2.Create the solar collector for collecting the heat
3. analyse the energy audit

List of Experiments

1. Performance analysis of Heat Pipe
2. Parallel flow and counter flow heat exchanger.
3. To estimate the COP of a vapour compression refrigeration system by solar(Refrigerator).
4. To find the solar flat plate collector efficiency.
5. To find direct solar incident flux absorbed by using Pyranometer orconcentraticparabolic collector.
6. Case study for energy audit.
7. Study of shell and tube heat exchanger
8. Study of fuel cell energy
9. Study of ocean thermal energy
10. Study of Solar cell fundamentals

REFERENCE BOOKS :

Online Learning Resources:

https://onlinecourses.nptel.ac.in/noc21_ch11/preview

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code	21D32201	ENERGY CONSERVATION AND AUDIT (21D32201)	L	T	P	C
Semester	II		3	0	0	3

Course Objectives:

1. To impart knowledge on Thermodynamics systems and entropy relationships.
2. To understand the heat exchanger for heat flow.
3. To develop the technologies for energy conservation
4. To understand the thermal insulation and refractories
5. To design of waste heat recovery systems.

Course Outcomes (CO): Student will be able to

1. To apply the knowledge of mathematics, science and engineering fundamentals to model the energy conversion phenomenon.
2. To investigate the effectiveness of energy conversion process in mechanical power generation for the benefit of mankindappreciate concepts learnt in fundamentals good refractories and insulationapply the knowledge of waste heat recover systems.
3. Design of heat recovery systems.

UNIT – I Lecture Hrs:10

THERMODYNAMICS

Availability, energy and Anergy-Exergy, energy, entropy relationship- Degradation of energy – exergy analysis- exergy conservation- combustion, thermal efficiency, thermal losses; thermal balance sheets.

HEAT EXCHANGER THEORY:

Types Of heat exchangers - overall heat transfer coefficient – fouling factor - Design of heat Exchangers, L.M.T.D. and N.T.U. methods.

UNIT - II Lecture Hrs:8

ENERGY CONSERVATION:

Rules for efficient energy conservation – technologies for energy conservation – outline of waste heat and material reclamation, load management.

ENERGY AUDITING:

A definition- Level of responsibility- Control of Energy- Uses of Energy - Energy index - Cost index - Pie charts-sankey diagrams Load profiles - Types of energy audits- General energy audit- Detailed energy audit.

UNIT - III **THERMAL INSULATION & REFRACTORIES:** Lecture Hrs:10

Heat loss through un insulated and insulated surfaces; effect of insulation on current carrying wires – economic thickness of insulation – critical radius of insulation – properties of thermal insulators – classification of insulation materials – classification of refractories – properties of refractories – Criteria for good refractory material – application of insulating & refractory materials.

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UNIT - IV	**WASTE HEAT RECOVERY SYSTEMS:**	Lecture Hrs:10
Guideline to identify waste heat – feasibility study of waste heat – shell and tube heat exchangers – Thermal wheel – heat pipe heat exchanger – Heat pump – waste heat boilers – Incinerators.		
UNIT - V	**HEAT RECOVERY SYSTEMS:**	Lecture Hrs: 12
Liquid to liquid heat exchangers – regenerators, recuperaters, rotating regenerators – selection of materials for heat exchangers, U- tube heat exchanger, fluidized bed heat exchanger –economizer.		
TEXTBOOKS: 1. The role of Energy Manager, E.E.O., U.K. 2. The Energy conservation Design Resource Hand Book-The Royal architectural Institute of Canada. 3. Conduction Heat Transfer-Schneder Addition Wieslthy		
REFERENCE BOOKS : 1. Conduction of Heat in Solids-Carslaw& Jaeger. 2. Fundamentals of heat and mass transfer-R.C. Sachdev New Age InternationalPublishers 3. Heat Transfer By R.K. Rajput/ laxmi publication		
Online Learning Resources:		
https://onlinecourses.nptel.ac.in/noc20_mm20/preview		

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code	21D32202	ENERGY EFFICIENT ELECTRICAL SYSTEMS (21D32202)	L	T	P	C
Semester	II		3	0	0	3

Course Objectives:

1. To make students conversant about the underlying energy conversion theory between electrical and mechanical systems by introducing electromechanical energy conversion principles.
2. To expose the students to the concepts of various types of electrical machines and applications of electrical machines.
3. To acquaint the student with the concept of generation of electricity in power plant.

Course Outcomes (CO): Student will be able to

1. Use modeling/simulation parameters with standard equivalent circuit models to predict correctly the expected performance of various general-purpose electrical machines.
2. Compare accepted standards and guidelines to select appropriate electrical machines to meetspecified performance requirements.
3. Demonstrate an understanding of the fundamental control practices associated with rotating machines (starting, reversing, braking, speed control etc.
4. Set up testing strategies to evaluate performance characteristics of electrical machines.Design of autonomous systems using special electrical machines.Justify contemporary issues within and outside the electrical engineering profession.
5. Accessthe techniques, skills, and modern engineering tools necessary for electrical engineering practice. Choosethe scope of applicability of various types of electrical machines in real life

UNIT – I Lecture Hrs:10

THREE PHASE INDUCTION MOTROS:
Cage motors-equivalent circuit-speed-torque characteristics-performance characteristics-voltage unbalance-over motoring-slip ring induction motor characteristics multi speed motors.

SINGLE PHASE INDUCTION MOTORS:
Starting & running performance-split phase-capacitor type motor-characteristics-reluctance motor.

UNIT – II Lecture Hrs:8

ENERGY EFFICIENT MOTORS:
Constructional details-factors affecting efficiency-losses distribution-characteristics-calculation of payback period.

ECONOMICS OF POWER FACTOR IMPROVEMENT:
Simple pay back method-return on investment-life cycle analysis.

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UNIT – III		Lecture Hrs:10
ENERGY EFFICIENT LIGHTING: Terminology-cosine law of illumination-types of lamps-characteristics-design of illumination systems-good lighting practice-lighting control-steps for lighting energy conservation.		
UNIT – IV		Lecture Hrs:10
ECONOMICS OF ELECTRICAL ENERGY GENERATION: Definitions-connected load, maximum demand-demand factor-curve-base load and peck load.		
UNIT – V		Lecture Hrs: 12
ECONOMICS OF ELECTRICAL ENERGY DISTRIBUTION: Electrical load analysis-type of consumers& tariffs-line losses-corner losses-types of distribution systems- Kevin's law-loss load factor. **ECONOMICS OF ELECTRICAL DRIVES:** Selection of motors-types of loads-energy consumption during starting of ac and dc motors-braking of motors-plugging-regenerative braking.		
TEXTBOOKS: 1. Electrical Machinery: Fitzerland, Kingsley, Kusko-MCGraw Hill Ltd. 2. Energy-Efficient Electrical motors: John C.Andreas-Marcel Decker Inc.		
REFERENCE BOOKS : 1. Electrical Technology: Edward Hughes-ElLBS. 2. Energy Management and good lighting practice: Fuel Efficiency Booklet 12-eeo.		
Online Learning Resources:		
https://nptel.ac.in/courses/108/106/108106022/		

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code	21D32203	Waste Heat Recovery Systems (21D32203)	L	T	P	C
Semester	II	PE - III	3	0	0	3

Course Objectives:

1. To gain fundamental knowledge in energy generation, heat transfer in thermal engineering.
2. To reduce the impact global warming for betterment of living things to serve healthy life.

Course Outcomes (CO): Student will be able to

1. The students will acquire fundamental knowledge in energy generation, heat transfer in thermal engineering.
2. Students will get the ability solve problems using mathematical concepts and to use modern engineering tools, software and equipment to analyze and solve complex engineering problems.
3. The students will be able to solve real world problems and reduce the impact global warming for betterment of living things to serve healthy life.

UNIT - I	Introduction	Lecture Hrs:10

Rankine Cycle, Coupled cycles and combined plants, Energy resources and use, Potential for energy conservation, Optimal utilization of fossil fuels. Total energy approach.

UNIT - II	Waste Heat Recovery Systems	Lecture Hrs:8

selection criteria for waste heat recovery technologies - recuperators - Regenerators - economizers - plate heat exchangers - thermic fluid heaters - Waste heat boilers-classification, location, service conditions, design Considerations - fluidized bed heat exchangers - heat pipe exchangers - heat pumps – sorption systems.

UNIT - III	Prime Mover Exhausts	Lecture Hrs:10

Incineration plants; heat pump systems; thermoelectric devices. Utilization of low grade reject heat from power plants, Utilization of waste heat in refrigeration, heating, ventilation and air conditioning systems. Thermoelectric system to recover waste heat.

UNIT - IV	Energy Storage Systems	Lecture Hrs:10

Need for energy storage, Thermal, electrical, magnetic and chemical storage systems.

UNIT - V	Economic Analysis	Lecture Hrs: 12

Investment cost – economic concepts – measures of economic performance – procedure for economic analysis – examples – procedure for optimized system selection and design – load curves - sensitivity analysis – regulatory and financial frame work for cogeneration and waste heat recovery systems

TEXTBOOKS:

1. Goswami, D. Y., and Kreith, F. Energy Conversion . CRC Press, 2007.
2. Hewitt, G. F., Shires, G. L., and Bott, T. R. Process Heat Transfer . CRC Press, Florida, 1993.
3. Li, K. W., and Priddy, A. P. Power Plant System Design . John Wiley and Sons, New

York, 1985.

REFERENCE BOOKS :

1. Nag, P. K. Power Plant Engineering . Tata McGraw-Hill, New Delhi, 2001.
2. El-Wakil, Power Plant Engineeirng, Mcgraw-Hill
3. HoSung Lee, Thermal Design
4. Dincer, Rosen, Thermal Energy Storage Systems

Online Learning Resources:

https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-mm20/

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code	21D32204	TOTAL QUALITY MANAGEMENT (21D32204)	L	T	P	C
Semester	II	PE – III	3	0	0	3

Course Objectives:

1. The overall purpose of the course is to provide an understanding of the process of managing quality and managing services.
2. The principles of Quality, Quality Assurance, and Total Quality Management willprovide an insight into the concepts of Excellence and Best Value and the contribution of quality to strategic management.
3. This course aims to show how all the fundamental disciplines of business areintrinsically linked with the concepts of service excellence and quality. Because these concepts are so interrelated they can be shown to have a strategic importance to the culture and success of any organization.
4. There are many tools and doctrines that can be used for assessing product/service quality and selection of these tools can help in the pursuit of excellence. This course is designed to provide a valuable perspective for future business managers.

Course Outcomes (CO): Student will be able to

1. Understand the fundamental principles of Total Quality Management.
2. Choose appropriate statistical techniques for improving processes.
3. Develop research skills that will allow them to keep abreast of changes in the field of Total Quality Management

UNIT - I	Lecture Hrs:10

TQM – Overview, Concepts, Elements – History-Quality Management Philosophies-Juran, Deming, Crosby , Feigenbaum, Ishikawa– Stages of Evolution– Continuous Improvement – Objectives – Internal and External Customers. Quality Standards – Need for Standardization - Institutions – Bodies of Standardization, ISO 9000 series – ISO 14000 series – Other Contemporary Standards – ISO Certification Process-Third Party Audit

UNIT - II	Lecture Hrs:8

Process Management- Quality Measurement Systems (QMS) – Developing and Implementing QMS –TQM Tools & Techniques- 7 QC Tools- 7 New QC Tools.
Problem Solving Techniques - Problem Solving Process – Corrective Action – Order of Precedence– System Failure Analysis Approach – Flow Chart – Fault Tree Analysis – Failure Mode Assessment and Assignment Matrix – Organizing Failure Mode Analysis – Pedigree Analysis.

UNIT - III	Lecture Hrs:10

Quality Circles – Organization – Focus Team Approach – Statistical Process Control – Process Chart – Ishikawa Diagram – Preparing and using Control Charts.

UNIT - IV	Lecture Hrs:10

Quality Function Development (QFD) – Elements of QFD – Benchmarking-Types-Advantages & Limitations of Benchmarking – Taguchi Analysis – Loss function - Taguchi

Design of Experiments, Robust Design, Poka-yoke, Kaizen, Deming Cycle.		
UNIT - V		Lecture Hrs: 12
Value Improvement Elements – Value Improvement Assault – Supplier Teaming; Business Process Reengineering & Elements of Supply Chain Management. Six Sigma Approach – Application of Six Sigma Approach to various Industrial Situations.		
TEXTBOOKS: 1. Total Quality Management,DakhBesterfield, Pearson Edu. 2. Total Quality Management, K.ShridharBhat, Himalaya.		
REFERENCE BOOKS : 1. Quality management, Howard Giltow-TMH 2. Quality management, Evans. 3. Quality management, Bedi		
Online Learning Resources:		
https://onlinecourses.nptel.ac.in/noc21_mg03/preview		

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code	21D32205	SOLAR REFRIGERATION & AIR CONDITIONING (21D32205) PE – III	L	T	P	C
Semester	II		3	0	0	3

Course Objectives:

1. To learning the fundamental of review of psychometric
2. To Study of various refrigeration cycles and evaluate performance using Mollier charts and/ or refrigerant property tables.
3. To Comparative study of different refrigerants with respect to properties, applications and environmental issues.
4. To understand the basic of solar thermal energy storage.
5. To Study of the various equipment-operating principles, operating and safety controls employed in solar refrigeration systems.

Course Outcomes (CO): Student will be able to

1. The fundamental principles and applications of refrigeration system.
2. Obtain cooling capacity and coefficient of performance by conducting test on vapour compression refrigeration systems.
3. Present the properties, applications and environmental issues of different refrigerants.
5. Calculate cooling load for solar refrigeration systems.
6. Operate and analyze the refrigeration systems.

UNIT – I Lecture Hrs:10

Review of Psychometric and (Air-conditioning) cooling load calculations-outline of Vapour Compression Refrigeration Systems – Cycle on p-h and T-o charts – C.O.P – Simple problems using property tables.

UNIT – II Lecture Hrs:8

Principle of working of working of vapour Absorption Refrigeration, steam jet refrigeration, thermoelectric refrigeration – classification of refrigerants – Desirable properties of ideal refrigerant - Properties of solvent - Solvent refrigerant combination properties.

UNIT – III Lecture Hrs:10

Solar cooling systems: vapour compression systems, Rankine cycle, Striling cycle, using P.V.Modules. Solar operated vapour absorption systems – vapour jet refrigeration systems.

UNIT – IV Lecture Hrs:10

Solar thermal energy storage - Active and passive systems TROMBE wall – equivalent thermal circuit - Solar green houses.

Solar cooling and dehumidification: Desiccant cooling - Solid and liquid desiccants - improving desiccant cycles - hybrid systems.

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UNIT – V		Lecture Hrs: 12
Non –mechanical systems - Australian Rock system – Solar assisted Heat Pump – Economics of solar cooling systems. Simulation of solar thermal systems - Salient features of DYNSYS, TRNSYS – model formulation – flow diagram of cooling systems.		
TEXTBOOKS: 1. A course in Refrigeration & Air –conditioning, S.Domakundwar&S.C.Arora 2. Principles of Solar engineering, F.Kreith&J.F.Kreider, McGraw Hill Book company		
REFERENCE BOOKS : 1. Solar Cooling & Heating Volumes, I,II,III., T.NegatVezirogulu 2. Entrepreneurship Development in New & Renewable Energy Technologies APPC & IREDA		
Online Learning Resources:		
https://onlinecourses.nptel.ac.in/noc21_me85/preview		

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DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code	21D32206	DESIGN OF WIND ENERGY SYSTEMS (21D32206) PE – IV	L	T	P	C
Semester	II		3	0	0	3

Course Objectives:

1. To knowledge onwind energy systems.
2. To understand wind resource characteristics and assessment; anemometry; wind statistics; speed frequency distribution
3. To analysis of wind turbine blade; effect of stall and blade pitch on coefficient of power
4. To design of Wind farm electrical design, Planning of wind farms,

Course Outcomes (CO): Student will be able to

1. Understand the state of art of wind energy technology
2. Know the atmospheric turbulence
3. Variable speed operation, effect of wind turbulence
4. Design of wind mill.

UNIT – I Lecture Hrs:10

Historical developments, latest developments, state of art of wind energy technology, turbine rating, cost of energy, wind power plant economics, installation and operation costs, decommissioning, Indian scenario and worldwide developments, present status and future trends

UNIT – II Lecture Hrs:8

Nature of atmospheric winds; wind resource characteristics and assessment; anemometry; wind statistics; speed frequency distribution, effect of height, wind rose, Weibull distribution, atmospheric turbulence, gust wind speed, effect of topography.

UNIT – III Lecture Hrs:10

Design of wind turbine blade; effect of stall and blade pitch on coefficient of power vs tip speed ratio and cut-out wind speeds, blade materials, design characteristics, multiple stream tube theory, vortex wake structure; tip losses; rotational sampling, wind turbine design programs, aerodynamic loads, tower shadow, wind shear, blade coning, gyroscopic, transient and extreme loads.

UNIT – IV Lecture Hrs:10

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. Power electronics Converter and Inverter interfaces for wind energy utilization system for isolated and grid connected system.

UNIT - V Lecture Hrs: 12

Wind farm electrical design, Planning of wind farms, special application for developingcountries, maintenance and operation, wind farm management, site selection. Environmental assessment; noise, visual impact etc. Instrumentation, data loggers, remote monitoring and control.

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TEXTBOOKS:
1. Paul Gipe, Wind Energy Comes of Age, John Wiley & Sons Inc.
2. Ahmed: Wind Energy Theory and Practice, PHI, Eastern Economy Edition, 2012
3. L.L. Freris, Wind Energy Conversion System, Printice Hall.
REFERENCE BOOKS :
1. Tony Burton et al, Wind energy Hand Book, John Wiley & Sons Inc.
2. Directory, Indian Wind Power 2004, CECL, Bhopal.
Online Learning Resources:
https://onlinecourses.nptel.ac.in/noc21_ch11/preview

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DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code	21D32207	ENERGY RESOURCES (21D32207)	L	T	P	C
Semester	II	PE – IV	3	0	0	3

Course Objectives:

1. 1.To impart knowledge on commercial energy
2. To know the solar radiation measurements
3. To understand the wind data and energy estimation.
4. To know the Fuel cell – principle of working - various types - construction and applications.

Course Outcomes (CO): Student will be able to

1. Future projections of consumption pattern - Sector-wise energy consumption.
2. photovoltaic conversion of solar energy, types of solar cells
3. safety and environmental aspects
4. Urban waste to energy conversion

UNIT - I	COMMERCIAL ENERGY	Lecture Hrs:10

Coal, Oil, Natural Gas, Nuclear power and Hydro - their utilization pattern in the past, present and future projections of consumption pattern - Sector-wise energy consumption – environmental impact of fossil fuels – Energy scenario in India – Growth of energy sector and its planning in India.

UNIT - II	SOLAR ENERGY	Lecture Hrs:8

Solar radiation at the earth's surface – solar radiation measurements – estimation of average solar radiation - solar thermal flat plate collectors - concentrating collectors – solar thermal applications - heating, cooling, desalination, drying, cooking, etc – solar thermal electric power plant - principle of photovoltaic conversion of solar energy, types of solar cells - Photovoltaic applications: battery charger, domestic lighting, street lighting, water pumping etc - solar PV power plant – Net metering concept.

UNIT - III	WIND ENERGY	Lecture Hrs:10

Nature of the wind – power in the wind – factors influencing wind – wind data and energy estimation - wind speed monitoring - wind resource assessment - Betz limit - site selection - wind energy conversion devices - classification, characteristics, applications – offshore wind energy – Hybrid systems - safety and environmental aspects – wind energy potential and installation in India - Repowering concept.

UNIT - IV	BIO-ENERGY	Lecture Hrs:10

Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - direct combustion – biomass gasification - pyrolysis and liquefaction – biochemical conversion - anaerobic digestion - types of biogas Plants - applications - alcohol production from biomass – bio diesel production – Urban waste to energy conversion - Biomass energy programme in India.

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UNIT - V	**OTHER TYPES OF ENERGY**	Lecture Hrs: 12

Ocean energy resources - principle of ocean thermal energy conversion (OTEC) - ocean thermal power plants - ocean wave energy conversion - tidal energy conversion – small hydro – geothermal energy - geothermal power plants – hydrogen production and storage - Fuel cell – principle of working - various types - construction and applications.

TEXTBOOKS:

1. Sukhatme, S.P., Solar Energy, Tata McGraw Hill, 1984.
2. Twidell, J.W. and Weir, A., Renewable Energy Sources, EFN Spon Ltd., 1986.
3. Kishore VVN, Renewable Energy Engineering and Technology, Teri Press, New Delhi, 2012
4. Peter Gevorkian, Sustainable Energy Systems Engineering, McGraw Hill,2007

REFERENCE BOOKS :

1. Kreith, F and Kreider, J. F., Principles of Solar Engineering, McGraw-Hill, 1978.
2. Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, OxfordUniversity Press, U.K, 1996

Online Learning Resources:

https://onlinecourses.nptel.ac.in/noc21_ch11/preview

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
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(ENERGY SYSTEMS)

Course Code	21D32208	OPTIMIZATION OF ENGINEERING DESIGN (21D32208)	L	T	P	C
Semester	II	PE - IV	3	0	0	3

Course Objectives:

1. To identify the optimization methods.
2. To understand the unconstrained optimization
3. To analyse the dynamic programming solving the problems.

Course Outcomes (CO): Student will be able to

1. understand the non-linear unconstrained optimization
2. Get the geometric programming
3. The sensitivity analysis. for change in the constraints

UNIT - I	SINGLE VARIABLE NON-LINEAR UNCONSTRAINED OPTIMITION:	Lecture Hrs:10

One dimensional Optimization methods:-Uni-modal function, elimination method, Fibonacci method, golden section method, interpolation methods- quadratic & cubic interpolation methods.

UNIT - II		Lecture Hrs:8

Multi variable non-linear unconstrained optimization: Direct search method – Univariant Method – pattern search methods – Powell's – Hook – Jeeves, Rosenbrock search methods – gradient methods, gradient of function, steepest decent method, Fletcher reeves method. Variable metric method.

UNIT - III		Lecture Hrs:10

GEOMETRIC PROGRAMMING:
Polynomials – arithmetic – geometric inequality – unconstrained G.P – constrained G.P
DYNAMIC PROGRAMMING:
Multistage decision process, principles of optimality, examples, conversion of final problem to an initial value problem, application of dynamic programming, production inventory. Allocation, scheduling replacement.

UNIT - IV		Lecture Hrs:10

Linear programming – formulation – Sensivity analysis. Change in the constrints, cost coefficients , coefficients of the constraints, addition and deletion of variable, constraints.
Simulation – Introduction – Types – Steps – application – inventory – queuing – thermal system.

UNIT - V		Lecture Hrs: 12

Integer Programming – introduction – formulation – Gomory cutting plane algorithm – Zero or one algorithm, branch and bound method.
STOCHASTIC PROGRAMMING:
Basic concepts of probability theory, random variables – distributions – mean, variance, Correlation, co variance, joint probability distribution – stochastic linear, dynamic programming.

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TEXTBOOKS:

1. Optimization theory & Applications/ S.S Rao/ New Age International
2. Introductory to operation research/Kasan& Kumar/Springar
3. Optimization Techniques theory and practice / M.C Joshi, K.M Moudgalya/ Narosa Publications.
4. S.D Sharma/Operations Research

REFERENCE BOOKS :

1. Operation Research/H.A. Taha/TMH
2. Optimization in operations research/R.L Rardin
3. Optimization Techniques/Benugundu&Chandraputla/Person Asia.

Online Learning Resources:

http://home.iitk.ac.in/~dasgupta/teaching/optim/

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(ENERGY SYSTEMS)

Course Code	21D32209	ENERGY OPERATIONS LABORATORY (21D32209)	L	T	P	C
Semester	II		0	0	4	2

Course Objectives:

1. To estimate the load and solar panel requirement
2. To study the payback period for solar water heater.
3. To estimate the energy efficiency.
4. To estimate the lift force in wind tunnel.

Course Outcomes (CO): Student will be able to

1. Understand the solar panel
2. Know the drag force and lift for wind tunnel

LIST OF EXPERIMENTS

1. Estimation of Load & Solar Panel Requirement for an house hold
2. Study of plant location of wind mills
3. Calculation of payback period for domestic solar water heater – A case study
4. Industrial visit of mind mills
5. Study on captive power generation of an industry
6. Study of Energy efficient building
7. Estimation of drag force by using wind tunnel
8. Estimation of lift force by using wind tunnel
9. Study of aerofoil blade variables and power output
10. Study of Solar Street Lighting and Lanterns

REFERENCE BOOKS :

Online Learning Resources:

https://web.iitd.ac.in/~arunku/files/CVL212_Y15/Lab_CVL212v1.pdf

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Course Code	21D32210	RENEWABLE ENERGY SYSTEMS LABORATORY (21D32210)	L	T	P	C
Semester	II		0	0	4	2

Course Objectives:

1. To study the solar PV systems
2. To study the wind energy generator, hydel power

Course Outcomes (CO): Student will be able to

1. Gain the knowledge on solar PV energy systems
2. Develop the hydel power and wind power systems

LISTOFEXPERIMENTS:

1. Study on Solar PV Energy System.
2. Experiment on "VI-Characteristics and Efficiency of 1kWp Solar PV System".
3. Experiment on "Shadowing effect & diode based solution in1kWp Solar PV system".
4. Experiment on Performance assessment of Grid connected and Standalone 1kWp Solar Power System.
5. Study on Wind Energy Generator.
7. Experiment on Performance assessment of micro Wind Energy Generator.
8. Study on Hybrid (Solar-Wind) Power System.
9. Experiment on Performance Assessment of Hybrid (Solar-Wind) Power System.
10. Study on Hydel Power.
11. Study on Performance Assessment of 100W Fuel

REFERENCE BOOKS :

Online Learning Resources:

http://se.iitmandi.ac.in/energy_engg.php

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code	21D32301	ENERGY ECOLOGY & ENVIRONMENT (PE - V)	L	T	P	C
Semester	III		3	0	0	3

Course Objectives:

1. To learn about energy source for earth its radiation
2. Understanding of biosphere and components of ecosystems.
3. Knowledge on energy transaction
4. To analysing the environmental components
5. Knowledge on sustainable world bio systems

Course Outcomes (CO): Student will be able to

1. Justify a scientific claim that free energy is required for living system to maintain organization
2. Predict how changes in free energy availability affect organisms, populations, and ecosystems.
3. Ability to select and use suitable environmental components.
4. Get the concept of pollution.

UNIT - I	Lecture Hrs:10

Energy source for earth – sun – its radiation – its absorption and reflection. Various renewable and non- renewable resources.

UNIT - II	Lecture Hrs:8

Boisphere – Energetics of the biosphere – Concepts of Ecology – Components of Ecosystems.

UNIT - III	Lecture Hrs:10

Energy transactions in biosphere – photo synthesis and producers – Herbivones – Carnivones – decomposers – Energy transfers & food wells.

UNIT - IV	Lecture Hrs:10

Dependence on abiotic systems – biogeochemical cycles. Elements of Environment – Interrelationships in environmental components.

UNIT - V	Lecture Hrs: 12

Concepts of pollution and affecting the natural balances in energy systems. Energy concepts for a sustainable world bio – systems.

TEXTBOOKS:

1. Renewable Energy, Environment and Development, MaheshwarDayal, Konark Publishers Pvt. Ltd.,
2. Ecology and Environment, P.D. Sharma Rastogi Publications.

REFERENCE BOOKS :

1. Energy for a sustainable world, J.Goldenberg, T.B. Johnson, AmulyaK.Reddy& Robert Williams Willey Eastern Ltd.,
2. Concepts of Ecology, E.J.Kormondal , Prentice Hall India Ltd.,

Online Learning Resources:

https://onlinecourses.nptel.ac.in/noc19_ge23/preview

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R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
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(ENERGY SYSTEMS)

Course Code		PRODUCT PLANNING AND MARKETING	**L**	**T**	**P**	**C**
Semester	**III**	**Program Elective Course-V**	**3**	**0**	**0**	**3**

Course Objectives:

1) To explain the concept of new products
2) To identify the basic characteristics of diffusion of innovation process
3) To understand the effective Plan for Product
4) To explain different brand personality
5) To understand the Planning the Harvesting Strategy Implementation.

Course Outcomes (CO): Student will be able to

1.Knowlede on common sourse for product ideas.
2.Develop the Product Strategies
3. Statistical Models for Analyzing Test Market Data.
4. Building Loyalty Through Strategic Differentiation
5. Sequential Introduction of Brand Extension

UNIT - I		Lecture Hrs:10

Classification of New Products: New products success and failure. Definition of success and failure, the latent Factors Behind the Marketing Success of New Products, Failure of New product, Factors Influencing Failure, Failures preventing new product Failure, New Product Development process and models, Model 1-The Cyclical Approach, Model 11-New product process Management

Concept Development and Statistical Tools Used : Introduction Common Sources for Product Ideas, Concept Development Methods, Idea Screening, idea Screening Approaches, Concept Testing, Definition, Methodology of Data Collection for Concept Testing, Data Analysis Techniques for Concept Testing, Concept Screen Test Method, Weighted Scoring Method, Concept Screening Matrix

UNIT - II		Lecture Hrs:8

Diffusion of Innovation and Adoption Process : Introduction, Adoption Process, Five Stage Process, Time of Adoption, Characteristics of Adopters, Characteristics Affecting Adoption Rate, Diffusion of Innovation, Product Life Cycle Introduction, Basics of PLC, 3 Types of PLCs, Identification of Stages in a PLCSigma Method of Tracing the Product Life Cycle and Stages Identification.,

Product Mix : Introduction, Width, Length, Depth, And Consistency of Product mix, Product Lines, Product Strategies, Introduction, Types of Naming, Problem Faced due to Linguistic Differences, Branding Naming Strategies, Brand Naming Strategies, The Naming Process, The Dos and Don'ts While Naming Brands, Brand Names, Generalization.

UNIT - III		Lecture Hrs:10

Test Marketing: Introduction, Objectives of Test Marketing-What to look for?, Pros and Cons of test Marketing, Decision Variables for Test Markets, Test Marketing Approaches, Types of Test Marketing Producers, Statistical Models for Analyzing Test Market Data, Data Project Method, Product Launch and Commercialization, The Product Launch Cycle, The Launch Mix, Issues in Launch, The Product Launch Process, Effective Plan for Product Launch, Product Launch Mistakes

Brand Identity: Introduction, What Identity is not ? Dimensions and Identity, Inner and Outer Identity, The Six Sided Prism, How to find Identity? Multiple Identities, Conclusion, Brand Image, Brand Images of Some of the Indian Brands, Techniques Used for Identifying the Brand Image, Brand Networking Techniques, Focus Groups, Constructive Techniques, Factor Analysis.

UNIT - IV		Lecture Hrs:10

Brand Personality: Introduction, Tools to Build/Understand Brand Personality, Brand personality Scale, Three Models to Build Brand Personality, Building Brand Personality Via the 4P's and Packaging, Building Brand Personality Bottom-up. Brand Positing and Repositioning Introduction, Grabbing the Mind Space, Positioning Statement, Determine the Positioning, The MDS Way, Image and Profile Analysis, Positioning through Correspondence Analysis, By factor Analysis, Positioning Analysis, by Discriminate Mapping, Repositioning, Brand Loyalty, Definition, Brand Loyalty Measurement Models, Preference Behavior Model, Purchase Probability Model, Brand Loyalty Analysis with Markov Chains, Strategies to Build Brand Loyalty, Building Loyalty Through Strategic Differentiation

UNIT - V		Lecture Hrs: 12

Line Extension: Introduction, Why Line Extension is so hard to resist ? A Good Marketing Strategy, Extension, Measuring the Line Extension Success Brand Extension Introduction, Asker and Keller's Success Factors, Internal and External Factors Affecting Firm, Inter Brand Success Factors, Sequential Introduction of Brand Extension, Process of Brand Extension, Brand Harvesting Introduction, Types of Harvesting, Activities Adopted during Harvesting Strategy, Planning the Harvesting Strategy Implementation.

TEXTBOOKS:

1. Gien L. Urban. John R. Hauser – "Design and Marketing of new products"
2. William L. Moore&Edgar – "Product Planning and Management", A. Pessemier AGILE MANUFACTURIN
3. Dr.C. Anandan "Product Management". Tata McGraw Hill Education Pvt. Ltd.,

REFERENCE BOOKS :

1. Philip Kotler. "Marketing Management " Person Eduction Pvt Ltd.,
2. Dr.VenuGopalRao. "Product and Brand Management" Himalaya Publications.

Online Learning Resources:

https://onlinecourses.nptel.ac.in/noc19_mg48/preview

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DEPARTMENT OF MECHANICAL ENGINEERING
(ENERGY SYSTEMS)

Course Code		RAPID PROTOTYPING TECHNOLOGIES	L	T	P	C
Semester	III	Program Elective Course- V	3	0	0	3

Course Objectives:

1.To impart knowledge on rapid prototyping technologies
2. To identifying the selective laser sintering
3. To know the solid ground curing and LOM materials
4. To analyse the Indirect Rapid tooling.
5. To understand the Rapid Manufacturing Process Optimization

Course Outcomes (CO): Student will be able to

1.Empathize with a broad group of RP systems.
2.Get their needs process details data preparation.
3. Develop the 3-D printer, HP system
4. Analyze the Rapid tooling
5. Surface generation from point cloud, Surface modification-data transfer to solid models.

UNIT - I		Lecture Hrs:10

Introduction: Need for the compression in product development, History of RP systems, Survey of applications, Growth of RP industry and classification of RP systems.

Stereo Lithography Systems: Principle, Process parameter, Process details, Data preparation, Data files and machine details, Application.
Selective Laser Sintering: Type of machine, Principle of operation, Process parameters, Data preparation for SLS, Applications.

UNIT - II		Lecture Hrs:8

Fusion Deposition Modelling: Principle, Process parameter,Path generation, Application
Solid Ground Curing: Principle of operation, Machine details, Applications.

UNIT - III		Lecture Hrs:10

Laminated Object Manufacturing: Principle Of Operation, LOM materials.
Process details, application.

Concepts Modelers: Principle, Thermal jet printer, Sander's model market, 3-D printer. GenisysXs printer HP system 5, Object Quadra systems.

UNIT - IV		Lecture Hrs:10

LASER ENGINEERING NET SHAPING (LENS)
Rapid Tooling: Indirect Rapid tooling -Silicon rubber tooling –Aluminum filled epoxy tooling Spray metal tooling, Cast kirksite, 3Q keltool, etc, Direct Rapid Tooling Direct. AIM, Quick cast process, Rapid Tool, DMILS, Prometal, Sand casting tooling, Laminate tooling soft, Tooling vs. hard tooling.

UNIT - V		Lecture Hrs: 12

Rapid Manufacturing Process Optimization: Factors influencing accuracy, Data preparation errors, Part building errors, Error in finishing, Influence of build orientation. **Allied Processes:** Vacuum casting, surface digitizing, Surface generation from point cloud, Surface modification-data transfer to solid models.
TEXTBOOKS: 1. Rapid Prototyping and Tooling by Hari Prasad & K.S. Badhrinarayan/ Page Turners 2. Paul F. Jacobs- "**Stereo lithography and other RP & M Technologies**", SME, NY 1996.
REFERENCE BOOKS : 1. Flham D.T &Dinjoy S.S - "**Rapid Manufacturing**" Verlog London 2001. 2. Lament wood, "**Rapid automated",** Indus press New York
Online Learning Resources:
https://onlinecourses.nptel.ac.in/noc20_me50/preview

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Course Code		**Open Elective**	**L**	**T**	**P**	**C**
Semester	**III**	**Mechatronics**	**3**	**0**	**0**	**3**

Course Objectives:

To impart knowledge on

To impart knowledge on about the elements and techniques involved in Mechatronics systems which are very much essential to understand the emerging field of automation.

Course Outcomes (CO): Student will be able to

1.Students can able to understand the concepts,need and importance of mechatronics.
2. They can able to know the concepts of 8085 microprocessor, 8051 microcontroller
3. They can able to understand the Programmable peripheral Interface
4. Students can able to know the structure, programming and selection of PLC
5. They can able to know the working principle and design concepts of actuators, mechatronic system.

UNIT – I		Lecture Hrs:

Introduction to Mechatronics – Systems – Concepts of Mechatronics approach – Need for Mechatronics – Emerging areas of Mechatronics – Classification of Mechatronics. Sensors and Transducers: Static and dynamic Characteristics of Sensor, Potentiometers – LVDT – Capacitance sensors – Strain gauges – Eddy current sensor – Hall effect sensor – Temperature sensors – Light sensors.

UNIT – II		Lecture Hrs:

8085 MICROPROCESSOR AND 8051 MICROCONTROLLER
Introduction – Architecture of 8085– Pin Configuration – Addressing Modes –Instruction set, Timing diagram of 8085 – Concepts of 8051 microcontroller – Block diagram,.

UNIT – III		Lecture Hrs:

PROGRAMMABLE PERIPHERAL INTERFACE
Introduction – Architecture of 8255, Keyboard interfacing, LED display –interfacing, ADC and DAC interface, Temperature Control – Stepper Motor Control – Traffic Control interface.

UNIT – IV		Lecture Hrs:

PROGRAMMABLE LOGIC CONTROLLER
Introduction – Basic structure – Input and output processing – Programming – Mnemonics – Timers, counters and internal relays – Data handling – Selection of PLC.

UNIT – V		Lecture Hrs:

ACTUATORS AND MECHATRONIC SYSTEM DESIGN
Types of Stepper and Servo motors – Construction – Working Principle – Advantages and Disadvantages. Design process-stages of design process – Traditional and Mechatronics design concepts – Case studies of Mechatronics systems – Pick and place Robot – Engine Management system – Automatic car park barrier.

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Textbooks:
1.Bolton, "Mechatronics", Printice Hall, 2008 2. Ramesh S Gaonkar, "Microprocessor Architecture, Programming, and Applications with the 8085", 5th Edition, Prentice Hall, 2008.
Reference Books:
1. Michael B.Histand and Davis G.Alciatore, "Introduction to Mechatronics and Measurement systems", McGraw Hill International edition,2007. 2. Bradley D.A, Dawson D, Buru N.C and Loader A.J, "Mechatronics", Chapman and Hall, 1993. 3. Smaili.A and Mrad.F , "Mechatronics Integrated Technologies for Intelligent Machines", Oxford University Press,2007. 4. DevadasShetty and Richard A. Kolk, "Mechatronics Systems Design", PWS publishing company,2007. 5. Krishna Kant, "Microprocessors & Microcontrollers", Prentice Hall of India,2007. 6. Clarence W, de Silva, "Mechatronics" CRC Press, First Indian Re-print,2013
Online Learning Resources:
https://nptel.ac.in › courses › noc21 › SEM1 › noc21-me27