UNIVERSITY OF MUMBAI
No. UG/130of 2015-16

CIRCULAR:-

The Principals of affiliated Colleges in Science and the Heads of the recognized Science Institutions concerned are hereby informed that the recommendation made by the Faculty of Science at its meeting held on 11th August, 2015 has been accepted by the Academic Council at its meeting held on 31st August 2015 **vide** item No. 4.7 and subsequently approved by the Management Council at its meeting held on 31st August 2015 **vide** item No.12 and that in accordance therewith, in exercise of the powers conferred upon the Management Council under Section 54 (1) of the Maharashtra Universities Act, 1994 and the Ordinances 6293 and 6294 relating to the Renewable Energy Resources, Skill Oriented Course Under Kaushal Scheme(DDU) has been introduced, which is available on the University's web site (www.mu.ac.in) that the same has been brought into force with effect from the academic year 2016-17.

Deputy Registrar
Under Graduate Studies

MUMBAI – 400 032
14th December, 2015

To,

The Principals of affiliated Colleges in Science and the Heads of the recognized Science Institutions concerned.

A.C/4.7/31/08/2015
M.C/12/31/08/2015

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No. UG/130 -A of 2015-16 MUMBAI-400 032 14th December, 2015

Copy forwarded with compliments for information to :-

1) The Dean, Faculty of Science,
2) The Director, Board of Colleges and University Development,
3) The Controller of Examinations,
4) The Co-Ordinator, University Computerization Centre.

Deputy Registrar
Under Graduate Studies

...PTO

O.6293:- Renewable energy resources

Skill oriented course under Kaushal scheme(DDU)

		Credits		
		Skill Based	**General**	**Total**
	Semester – 1			
1.	Instrumentation		12	
2.	Fundamentals of energy system-I	9		
3.	Energy conversion system-I	9		
.	**O.6294:- Eligibility-** 12^{th} Passed	18	12	**30**
	Semester – 2 **Eligibility-** Successful Completion Of Semester 1or NSQF Level 4			
1.	Fundamentals of energy system-II		12	
2.	BIO-Energy –I	9		
3.	Energy conversion system –II	9		
		36	24	**60**
	Semester – 3 **Eligibility-**Successful Completion Of Semester 2 Or NSQF Level 5			
1.	Solar energy thermal Conversion I	9		
2.	Energy storage system-I		12	
3.	Solar Photovoltaic conversion-I	9		
	Semester – 4			
1.	Electronics		12	
2.	Solar Photovoltaic Energy Conversion-II	9		
3.	BIO-ENERGY II	9		
		72	48	**120**
	Semester – 5 **Eligibility-**Successful completion of Advanced Diploma**OR** NSQF Level 6			
1.	Project management:		12	

	Semester – 6			
1.	Other Renewable Energy sources-I	9		
2.	Energy efficiency in Buildings and ECBC		12	
3.	Energy management	9		
		108	72	**180**

Practical component: In addition to practical work, students will have to carry out mini projects related to syllabus theme and internship of specific duration advised by Industry partners or SSC. The skill component will have weightage of 60% and conventional course will have weightage of 40%.

3
Renewable Energy Syllabus structure

Semester	Theory 1	Theory 2	Theory 3	Practicals
I	Instrumentation	Fundamentals of energy system-I	Energy conversion system-I	**S1p1: Practical &miniproject**
Total marks	**100**	**100**	**100**	**100**
II	Fundamentals of energy system-II	BIO-Energy –I	Energy conversion system –II	**S2p2 Practical &miniproject**
Total marks	**100**	**100**	**100**	**100**
III	Solar energy thermal Conversion I	Energy storage system-I	Solar Photovoltaic conversion-I	**S3p3 Practical**
Total marks	**100**	**100**	**100**	**100**
IV	Electronics	Solar Photovoltaic Energy Conversion-II	BIO-ENERGY II	**S4p4 Practical &miniproject**
Total marks	**100**	**100**	**100**	**100**
V	Project management:	Wind energy-I:	Lasers and its applications	**S5p5 Project work**
Total marks	**100**	**100**	**100**	**100**
VI	Other Renewable Energy sources-I	Energy efficiency in Buildings and ECBC	Energy management:	**S6p6 project work**
Total marks	**100**	**100**	**100**	**100**

Practical component: In addition to practical work, students will have to carry out mini projects related to syllabus theme and internship of specific duration advised by Industry partners or SSC. The skill component will have weightage of 60% and conventional course will have weightage of 40%.

Semester I	Instrumentation

1. Fundamentals of measurements, Aims of measurement, Functional elements of typical measurement system (block diagram), standards of measurements (Mass, Length, time, current), Static characteristics (Accuracy, precision, sensitivity, linearity, repeatability, reproducibility, drift, dead zone, hysteresis resolution), Dynamic characteristics concept,

first, and second order system errors in measurements, transducers,

2. Measurement of displacement and force: measurement of displacement (variable resistance, capacitance, inductance method), measurement of force (Load cell, column type devices, cantilever beam)
3. Measurement of pressure: units of pressure and concept of vacuum, absolute gauge, and differential pressure, elastic transducers,(diaphragm, corrugated diaphragm, bellows and Bourden tube etc.) electrical tube LVDT, strain gauge, piezoelectric , pressure transducer calibration by dead weight tester method, measurement of flow meters, Bernoulli's theorem, venture tube, pilot tube, rotameter, ultrasonic flow meter),
4. Measurement of magnetic field,: Introduction to magnetic materials, hysteresis loop and its applications, Ballistic method for obtaining BH curve, measurement of magnetic field by search coil and hall probe,
5. Biomedical and environmental instruments: Block diagram of ECG, MRI, and BP apparatus. Pyranometer for solar radiation measurement, acoustic measurements, sound level meter, hair hygrometer, smoke density measurements.

Ref:

Instrumentation devices and systems by Rangan, Mani Sharma, TMH
Instrumentation measurements and analysis by NKRA, Chaudhary, TMH
Solar Energy by S P Sukhatme Mc Graw hill
Electricity and magnetism by Khare and Shrivastava
Medical instrumentation Karr-Brown
Air pollution by M N Rao, H V Nayak, TMH
Handbook of medical Instrumentation R S Khandpur TMH

Semester I	Fundamentals of energy system-I

Conventional and nonconventional energy sources

1.1 energy sources and world energy status

Energy sectors: domestic, transportation, agriculture, industry sector, energy scenario, world energy present situation, availability of conventional and nonconventional energy resources.

1.2 conventional energy sources

Fossil fuel, hydro resources, nuclear resources, coal, oil, gas, thermal power stations, comparison of various conventional energy systems, their prospects and limitations. Advantages and disadvantages of conventional energy sources.

1.3 nonconventional energy sources

Solar energy, wind energy, energy from biomass and biogas, ocean thermal energy conversion, tidal energy, geothermal energy, hydrogen energy, fuel cell, magneto hydrodynamic generator

Advantages and limitations of nonconventional energy sources

2. Fluid Mechanics:

2.1 Fluid properties and classification of fluids:

Definition of fluid, distinction between solids and fluid and liquid and gas continuum; mass density, specific volume, viscosity, Newton's law of viscosity, Newtonian and Non-Newtonian fluids, ideal and real fluids, steady and unsteady flow, uniform and non-uniform flow, laminal and turbulent flow, compressible and incompressible flow, surface tension, definition, unit and dimensions

2.2 Fluid pressure and its measurement:

Definition of pressure, units and dimensions, pressure at a point, Pascal's law, Hydrostatic pressure law, absolute and gauge pressure, measurement of pressure, simple manometer and differential manometer, theory and problems,

2.3 Kinematics of fluid flow:

Description of fluid flow, Lagrange and Eulerian approaches, definition of path line, streamline streak

line, stream tube, acceleration of flow.
2.4 Dynamics of fluid flow:

Concept of inertia, force and other forces causing motion, derivation of Euler's equation, modification of Bernoulli's equation, problems on Bernoulli's equation without and with losses.
2.5: Flow measurements:

Flow through orifices, classification, hydraulic Coefficient of an Orifice and relation between them. Equation for coefficient of velocity, problems, flow through pipes, venture meter.

Ref:

Nonconventional energy sources by G D Rai, Khanna Publications,
Nonconventional Energy Resources, B H Khan, McGraw Hill
Publications. For fluid mechanics:

Fluid Mechanics and fluid power engineering by D S Kumar, S K Kataria and sons
Fluid Mechanics and Hydraulic machines by R K Bansal, Laxmi publications
Theory and applications of fluid mechanics, K Subramanya, TMH outline series, TMH

Semester I	Energy conversion system-I

1. Elements of electromechanical energy conversion: introduction: Introduction, salient aspects of conversions, energy balance, magnetic fields system, energy and co-energy, a simple electromechanical system, energy in terms of electrical parameters, rotary motion, dynamic equations, and system model of a simple system.
2. DC generators: Simple loop generator, practical generator, Yoke, pole cores and pole shoes, pole coils, armature core, armature windings, commutator, brushes and bearings, pole pitch, conductor, types of generators separately excited, Self excited generators: shunt wound, series wound, compound wound, measurement of generator efficiency, iron lasses: Hysteresis loss, eddy current loss, total loss in a DC generator. Copper , magnetic and mechanical losses, stray losses, constant and standing losses.
3. Generator characteristics: Characteristics of DC generator, separately excited generator: no-load saturation characteristics, load saturation characteristics
4. DC Motor: Motor principle, comparison of generator and motor action, significance of back emf, Voltage equation of a motor, condition for maximum power, torque, shaft torque, speed of DC motor, speed regulation torque and speed of dc Motor, motor characteristics, characteristics of series and shunt motors, compound motors: commutative- compound motors, differential compound motors, performance curves of shunt and series motors, comparison of series and shunt motors, power stages

Ref:

Textbook of Electrical Technology Vol II BL Theraja and AK Theraja S Chand Publications
Electrical machines by P S Bhimbra

Semester II	Fundamentals of energy system-II

1. Introduction to laws of thermodynamics- first and second,: perfect gas laws
2. Heat transfer: conduction teat transfer, convection, radiation, heat exchanger and insulation
3. Refrigeration and air conditioning: introduction, air refrigeration, vapour compression cycle, refrigerants, recent substitute for refrigerants

Ref:
Engineering thermodynamics by Nag PK, TMH,

Fundamentals of Thermodynamics by Sonntag, Borgnakke Wiley
Refrigeration and air conditioning by Arora C P. TMH,
Principles of air conditioning by Dossat R J. PHI
Heat transfer by Sukhatme, Heat transfer by P K Nag

Semester II	BIO-Energy –I

1. Basics of biomass study, biomass types, its advantages and drawbacks, Indian scenario, characteristics, conversion mechanisms, fuel assessment studies,
2. Biomethanation: microbial systems, phases in biogas production, parameters affecting gas production, biogas plants: types, design, constructional details and comparison, Factors affecting the design
3. Methods for maintaining biogas production: Insulating the gas plant, compositing, hot water circulation, use of chemicals, solar energy systems
4. Commissioning and management of biogas plant: commissioning and management of biogas plant, community plant, biogas applications, effect of biogas on engine performance. Socio-economic aspects of biogas, cost benefit analysis of biogas plant
5. Reactors: Immobilised reactors UASB reactor, fixed film, hybrid, bi-phase reactor
6. Economics and environmental aspects: energy effectiveness and cost effectiveness, history of energy consumption and cost, economic and competitive issues for biogas energy. Policy and market interventions (subsidy, credits, carbon markets) Environmental aspects of bioe3nergy conversion
7. Municipal and industrial waste to energy conversion: solid waste, definition, sources, types and composition of solid waste, properties of solid waste, municipal solid waste: physical chemical and biological properties, Waste minimization and recycling of waste, waste treatment and disposal size reduction: aerobic composting and incineration, measures of mitigate environmental effects due t incineration.

   Waste disposal: land fill method of solid waste disposal, layout and preliminary design of land fill, composition, characteristics, generation. Movement and control of Landfill leachate and gases, environmental monitoring system for landfill gases

   Industrial solid waste: Composition of industrial solid waste, biodegradable and non-biodegradable hazardous, methods of de-oxification, legal aspects of municipal solid waste collection.

   Hazardous waste management: definition, identification, sources and nature of hazardous waste, hazardous waste control, impact on environment, assessment of hazardous waste sites, underground storage tanks construction, installation and closure.
8. Biofuel: Ethanol and methanol production from cellulosic biomass, biodiesel production from nonedible oil seeds.

Ref:

Bioenergy technology, thermodynamics and costs, David Boyles, Ellis HoknoodChinchester, 1984
Nonconventional energy sources GD Ray Khanna Publ.
Nonconventional Energy resources by BH Khan TMH
Biogas Technology, Khandelwal KC, Mahdi SS, TMH
Biomass Classification Principles and technologies, by Tom B Reed, Noycee Data Corporation
Bio-Energy for rural Energisation, by RC Maheshwari, Concepts Publications 1997
Best practices manual for Biomass Briquetting IREDA 1997
Energy Conversion Systems by Rakosh das Begamudre, New Age International Publishers New Delhi 2000
The Briquetting of Agricultural waste for fuel FAO Energy and Environment paper by S. Ericksson,

1990

Basics of solid and Hazardous waste management technology, by Shah, Kanti L. PHI 1997
Solid waste management in developing countries INSDOC New Delhi 1983
Waste disposal in engineered landfills, by Manoj Datta, NarosaPubli. 1997

Semester II	

Energy conversion system -II

1. Speed control of DC motors:

   Factors controlling motor speed, speed control of shunt motors: flux control, armature or rheostatic control, voltage control; Speed control of Series motors: flux control and variable resistance in series with motor, Measurement of motor efficiency.
2. Transformers

   Working principle construction, Types: Core type, Shell type, Elementary theory of an ideal transformer, DMF Equation of transformer, voltage transformation ratio (K), Transformer with losses but no magnetic leakage, transformer on no-load, and on load. Transformer with winding resistance but with no magnetic leakage, with magnetic leakage, transformer efficiency,

   Three phase transformers connection, star star or Y/Y connections. Delta Delta, Wye/Delta, Delta/Wye connection.
3. Induction Motors:

   Classification of Ac motor, Induction motor- general principle, construction, squirrel cage rotor, phase wound motor, production of rotating field, three phase supply, mathematical proof, slip, frequency of rotor current, torque speed curve, current speed curve,
4. Single phase motors: types, single phase induction motor, double field rotating theory, self making single phase motor self starting. Capacitor start motors types. Repulsion type motors, repulsion principle,

Ref:

Textbook of Electrical Technology Vol II BL Theraja and AK Theraja S Chand Publications
Electrical machines by P S Bhimbra

Semester III	Solar energy thermal Conversion I

1. Basics of solar energy systems: different types of RE sources, Sun as source of energy, solar radiation, extra terrestrial at earth's surface-horizontal tilted surface, estimation of radiation, alternation of solar radiation by atmosphere, effect of orientation of receiving surface
2. Basic sun-earth angles: angle of latitude, declination angle, hour angle inclination angle, Zenith angle, solar azimuth angle, tilt angle, surface azimuth angle, angle of incidence, local solar time,
3. Solar radiation: solar radiation data, estimation of monthly avg, daily total radiation on horizontal surface, estimation of monthly, avg, daily, diffuse radiation on horizontal surface. Monthly avg, daily global radiation on tilted surface
4. Measurement of solar radiation: measurement of solar radiation: pyranometer, pyrheliometer, sunshine recorder, radiation characteristics of opaque materials, radiation transmission through covers and absorption of collectors.
5. The solar energy option: An overview of thermal applications: devices for thermal collection and storage, thermal applications,
6. Liquid flat plate collectors(FPC): definition, characteristics features of FPC, performance

analysis, transmitivity- absorptivity product, overall loss coefficient and heat transfer corelations, collector efficiency factor, effects of various parameters on performance, advantages of FPC, alternatives to the conventional collector

7. Solar air heaters and water heater: introduction, performance analysis of solar air heater, types of air heaters- collector with non porous absorber, collector with porous absorber, testing procedure of solar air heater, solar water heating system: thermosiphon and forced flow.

References:

Nonconventional energy sources by GD Ray
Nonconventional energy Resources by BH Khan
Solar enrgy by Sukhatme TMH
Solar energy by Sukhatme&Nayak TMH
Solar energy by Garg Prakash, TMH
Smart grids by Jean Claude SabonnadiereNouredineHadjsaid Wiley public
Solar photovoltaics Fundamentals Technologies and applications by C S Solanki. PHI Handbook of Photovoltaic Science and Engineering, AntanioLuque, John Wiley and Sons 2002,
Solar Engineering of thermal processes By J A Duffe and W A Beckmann John Wiley and son 1991
Renewable and Efficient electric Power systems Gilbert M Masters, PHI
Principles of solar engineering by Kreith F and Krieder JF, Mc Graw Hill
Solar Passive building: Science and design, by MAS Malik, N K Bansal ,, A Kumar AS Malik, Pergamon press New York 1986
Solar Distillation, MAS Malik, GN Tiwari, A Kumar MS Sodha, Pergamon press New York 1982

Semester III	Energy storage system-I

1. Energy storage, need and different modes of energy storage
2. Electrochemical energy storage systems: Primary and secondary batteries, solid state and molten solvent batteries, lead acid batteries, NI_Cd and advanced batteries
3. Magnetic and electric energy storage systems: Superconducting magnet energy storage systems, capacitor and batteries,

Ref:

Fuel cell technology handbook edited by Gregor Hogers CRC press 2003,
Handbook of batteries and fuel cellBy David Linden McGraw Hill
Nonconventional Energy Sources by G D Ray
Nonconventional Energy Resources by Khan BH, TMH
High temperature solid oxide fuel cells: Fundamental design and applications by SC Singhal, Elsevier Publ.
Fuel cells for automotive applications- professional engineering Publishing UK ISBN 1-860584233, 2004

Semester III	Solar Photovoltaic conversion-I

1. Introduction, Solar cell fundamentals: semiconductors, p-n junction, generation of electron hole pair by photon absorption, photoconduction.
2. Solar cell characteristics, IV, Effect of variation of insolation and temperature, energy losses and efficiency, maximising the performance, cell size, Energy payback period (EPP).
3. Classification of solar cell: According to thickness of active material, junction structure, single crystal silicon solar cell, multi-crystalline, Gallium Arsenide cell, copper Indium dielectric cell, amorphous solar cell
4. Solar cell module, Panel, and constructions: solar cell, PV module, PV Pane, PV array,

Ref:

Nonconventional energy resources by BH Khan TMH
Nonconventional energy resources by g d Ray, Khanna Publications
Solar energy by Sukhatme&Nayak TMH
Solar energy by Garg Prakash, TMH
Smart grids by Jean Claude SabonnadiereNouredineHadjsaid Wiley public
Solar photovoltaics Fundamentals Technologies and applications by C S Solanki. PHI Handbook of Photovoltaic Science and Engineering, AntanioLuque, John Wiley and Sons 2002,
Solar Engineering of thermal processes By J A Duffe and W A Beckmann John Wiley and son 1991
Renewable and Efficient electric Power systems Gilbert M Masters, PHI
Principles of solar engineering by Kreith F and Krieder JF, Mc Graw Hill

Semester IV	Electronics

1. Basic electronic components: definition of resistance, capacitance, and inductance, concept of reactance and impedance, transformers, centre tapped, step up, step down, various energy losses in transformers.
2. Network theorems: Kirchhoff's laws, voltage and current divider circuits, Thevenin's theorem, Norton's theorem, superposition theorem, maximum powertransfer theorem. problems
3. Semiconductor devices: semiconductor diodes, transistors, CE, CB, CC configurations, current gains, biasing methods, Transfer characteristics of CE and CB, AC and DC load lines, transistor as a switch, and as amplifier, Frequency response of amplifier, UJT
4. OPAMPs: Block diagram of IC 741, ideal and practical characteristics, virtual ground, inv and non-inv amplifier with gain expression, adder subtracter, oscillators,
5. Power supplies: half wave, full wave, bridge rectifier, ripple factor, capacitor filter, difference between regulated and unregulated power supplies, line and load regulation, series and shunt regulators, current limiting,
6. Digital electronics: Binary number system, octal, hexadecimal. Addition, subtraction, using 1's and 2's complement. Basic logic gates, universal building blocks, DeMorgan's theorems.

Ref:

Electronic principles by Malvino, 7th edition, TMH
Principles of electronics by V K Mehta, S Chand Publi.
OpAMPs and linear Integrated circuits by RamakantGaikwad PHI
Integrated circuits by Botkar Khanna Publi
Digital principles and applications by Malvino Leach, TMH

Semester IV	

Solar Photovoltaic Energy Conversion-II:

1.Solar cell fabrication technology: Preparation of metallurgical, electronic and solar grade silicon, Production of single crystal, multi-crystaline, GaAs, Copper Indium Di-selenide, amorphous solar cell, wafering and doping, Thin film modules method of manufacture, procedure of masking, photolithography and etching, role of nano technology in solar cell, module lamination and fabrication

2. Solar PV system: Classification, standalone solar PV system, Grid interactive solar PV system, Hybrid solar PV system,

Battery technology: introduction, basic concepts, components of battery, operation of battery. Battery characteristics, classification of batteries, lead acid, Nickel Cadmium, Zinc Manganese dioxide

Inverter: Introduction, classification of inverter, single phase series inverter, single phase full bridge inverter single phase inverter output voltage control, single pulse width modulation, multiple pulse width modulation,

3. Smart Grid Technology: Evolution of electric grid, concept of smart grid, definition, need of smart grid, functions of smart grid, opportunities and barriers of smart grid, difference between conventional grid and smart grid, concept of resilient grid and smart grid, Role of smart meter in smart grid, real time prizing, smart appliances, automatic meter reading(AMR), smart sensors, smart grid life cycle: regulatory and cost recovery, strategy and planning, technology integration, business process readiness, compliance and risk management,

4. Solar PV Applications: grid interactive PV power generation, water pumping, lighting, medical refrigeration, village power, telecommunication and signalling

Ref:

Nonconventional energy Resources, By Khan BH, TMH
Nonconventional energy sources By G D Ray, Khanna Publ.
Solar Energy by SP Sukhatme and JK Nayak, TMH New Delhi
Solar energy by Garg Prakash, TMH
Smart grids by Jean Claude SabonnadiereNouredineHadjsaid Wiley public
Solar photovoltaics Fundamentals Technologies and applications by C S Solanki. PHI Handbook of Photovoltaic Science and Engineering, AntanioLuque, John Wiley and Sons 2002,
Solar Engineering of thermal processes By J A Duffe and W A Beckmann John Wiley and son 1991
Renewable and Efficient electric Power systems Gilbert M Masters, PHI
Principles of solar engineering by Kreith F and Krieder JF, Mc Graw Hill

Semester IV	BIO-ENERGY II

1. Thermochemical conversion of biomass
   Introduction to bioconversion, biomass composition, properties of biomass, thermal degradation, steps, Arrhenius law, kinetics, gas producers
2. Gasification: Principles of gasification, pre-treatment of biomass, physical treatment, mechanical grinding, chopping, moisture removing or adding, applications of binding agent, steaming, torrefaction, chemistry of gasification, types of gasifiers and zones: updraft gasifier, downdraft, cross draft, open core, fluidized bed gasifier (Principles, design and applications, models),
3. Gasifier applications; engine system its requirements, thermal applications,
4. Composter: wood burning stoves, principles of wood burning stoves, design: wood burning stoves
5. Pyrolysis: pyrolysis plants, their principles, products recovery from pyrolysis plants
6. Cogeneration: principle and classification (topping cycle, bottoming cycle, combined cycle, Rankine cycle) of cogeneration, layout of cogeneration system, cogeneration technologies, steam turbine systems, gas turbine cogeneration systems, combined cycles cogeneration systems, advanced cogeneration systems. Issues and applications of cogeneration technologies, technical parameters for cogeneration: heat to power ratio, quality of thermal energy needed. Load pattern, fuels available, system reliability, grid dependent system vs independent system, retrofit vs new installation, electricity buy-back, local environmental regulation. Instruments related to gasifiers studies.

Ref:

Fuel wood from waste land by Vimal OP, and Tyagi PD 1985, Agricole publishing academy New Delhi

Fuels from Biomass waste by Glass D L. and Emert M. Ann Arbor Science Publishing Inc, Michigan 1985

Progress in Biomass Conversion Vol. I by Tilman DA , Academic Press London

Prroducer Gas Local Electricity generation from wood and agricultural rresidues. By Kjellstorm N, 1980 FAO Publications

Nonconventional energy sources by GD Ray

Nonconventional energy Resources by BH Khan

Semester V	Project management

1. Introduction
2. Project management overview, plan, management priciples, life cycle and uncertainty
3. Project planning: scope, goals objectives success criteria, assumptions, risks, obstacles approval process
4. Project implementation: resource requirements, types of resources: men material, money
5. Project monitoring: evaluation, control, network technique, planning for monitoring and evaluation, audits, PMIS. Scheduling, PERT/CPM, Project communication,post project reviews.
6. Project team management: recruitment, organising, HR, team operating rules, project organisation, charting, compilation of contracts, practical, legal aspects, global tender, negotiations, insurance
7. Closing the project: termination types, strategic implementation, project in trouble, termination strategies, evaluation of termination possibilities, termination procedures.
8. Project inventory management

Ref:

Project management for 21st century – Benet P Lientz, Kathyn

Project management by Denislok

Project management by David Cleland

Project management by Gopalkrishnan

Project management by Harry, Maylorepearson

Semester V	Wind energy-I:

1. Basics of wind: causes of wind, types of winds, local and regional wind system, meteorology of wind: global circulation, forces influencing wind-pressure gradient force and Coriolis force, power in the wind
2. Wind measurement techniques: Measurement and instrumentation, wind data presentation, power law index, betz constant, terrain value, wind data characterisation, wind data studies, Weibull, Rayleigh and normal distributions,
3. Wind resource assessment: Atmospheric boundary layer, atmospheric stability, wind power conversion, wind power estimation, site survey and analysis
4. Wind mill site selection and micro siting: Site selection based on: anemometric dwind data, wind speed and direction, site topology, terrain, altitude, local ecology, project accessibility, land cost.; Micrositing: necessary parameters, building requirements, environmental aspects, prevailing conditions,

5. Aerodynamics and wind mill blade, theory of aerodynamicsblade element theory and aerofoil,
6. Wind energy conversion: wind mill, basic components of wind mill conversion system, types of wind mills based of various parameters, development of wind turbine, wind turbine terminology, wind turbine performance analysis,

Ref:

Power plant technology, E L Walil, Mac Graw Hill New York
Nonconventional Energy sources GD Rai, Khanna Pub.

Meteorological aspects of the utilisation of wind as an energy source, Technical note no 175, world meteorological Organisation, b

Wind turbines Fundamental Technologies applications, economics Enrich
Springer VerlagBerl;inHeidelberg 2000
Wind Energy system, G L Johnson, PHI

DNV-Riso guidelines for design off wind turbines, second edition, Riso national laboratory, Denmark 2002

Wind energy explained by JF Manwelll, JG McGowan and AL Rogers, John wiley and sons 2003
Report of EWEA, The economics of Wind Energy, march 2009,

Wind energy Handbook by T Burton et al. John Wiley 2004 Electric
machines, by I J Nagrath and D P Kothari TMH 2nd ed. 2003
Wind electrical systems by SN Bhadra, D Kastha and S Banerjee, Oxford Uni Press 2005, Electrical Technology by S Rao and B BParulekar, 3rd ed. Khanna pub 1995, Wind Energy data for India, Anna Mani and Dr Nooley, 1983

Semester V	Lasers and its applications

A Brief history of lasers, Einstein's prediction: The three processes, Einstein's relations, (Qualitative discussion only) pumping schemes, characteristics of types of lasers HE-NE and Ruby, applications of Lasers.

Sensors and transducers:

Overview- Need definition, and qualities of transducers, Temperature: thermocouple, thermistors, Platinum thermometer, IC, temperature sensors, Quartz thermometer, pyrometers, cryogenic temperature measurements. Light: sensors- phototransistors and photomultipliers,

Bioelectricity:

Electricity observed in living systems, origin of bioelectricity, sodium potassium transport, resting potential and action potential, Nernst's equation, conduction velocity, origin of compound action potential, neuron structure and function, an axon as cable, membrane resistance and capacitance Nano-materials:

Introduction, reduction of dimensions 3D, 2D, 1D, 0D materials, surface and interface effect., modelling of quantum size effect, synthesis of nano particles- bottom up and Top down approach, wet chemical method, idea of bio mimicking, naturally occurring nanocrystals,

Ref:

Lasers: An Introduction to Lasers Theory and Applications by M N Avadhanalu S Chand and co. Solid state Physics P Palanisamy, Scitech Publications

Sensors:

Instrument measurement and analysis by B C Nakra and KK Chaudhary TMH 16th Reprint ch 1.
Bioelectricity: Neuron ti Brain, By Kuffier, and Nicholas Sinauer Associates INC, Pub. Sundarland Massachusetts
Nano: Nanomaterials- synthesis, properties and applications, Edelstein, Camarata, Institute of

Physics Publishing, Bristol and Philadelphia
Introduction to nanotechnology By Charles P Poole John Wiley and Sons Publ.
Nanotechnology: Principles and practices by S K Kulkarni, Capital Publ.Co.

Semester VI	

Other Renewable Energy sources-I

1. Hydrogen Production: Electrolysis, catalytic methods, Thermo-chemical methods, Fossil fuel methods, Solar energy method,
2. Hydrogen storage: Hydrogen storage methods, utilisation of hydrogen gas, hydrogen as an alternative fuel, hydrogen transportation,
3. Nuclear reactions: mechanism of nuclear fission: nuclides radioactivity, decay chains, fission process, reactors, reactor materials
4. Reprocessing: Nuclear fuel cycles, spent fuel characteristics, role of solvent extraction in reprocessing and their equipment
5. Separation of reactor products: Fuel element dissolution, precipitation process, ion exchange, TBP and Thorax processes, Isotopes: principles of isotope separation,
6. Waste disposal and radiation protection: types of nuclear wastes, safety control and pollution control and abatement, International convention on safety aspects, radiation hazards.

References:
Nonconventional Energy Sources by G D Ray
Nonconventional Energy Resources by BH Khan TMH

Semester VI	Energy efficiency in Buildings and ECBC

1. Energy conservation in buildings: Introduction, criticality of resources (energy and water), heat loss heat gain its evaluation, thermal comfort improvement methods, IAQ requirements, electrical energy conservation, opportunities and techniques for energy conservation in buildings
2. Thermal behaviour of buildings: orientation and planning for environment, prciple s of heat thermal insulation, humidity, condensation, humidity and condensation, admittance method, building energy simulation, load calculation,
3. Efficient lighting and daylighting: principles of lights, artificial lighting, natural lighting, lighting and visual ability, light sources and luminaries, system design, impacts of lighting efficiency, installed interior and exterior lighting power.
4. Energy conservation in air conditioning system: energy conservation in pumps/fan/ blowers, refrigerating machines, heat rejection equipment, energy efficient motors, insulation
5. Indoor environmental requirements
6. Service hot water and pumping: mandatory requirements, solar water heating, equipment efficiency, supplementary water heating system, piping insulation, swimming pools

Ref:
Heating and cooling of Buildings: design for efficiency by J Krieder and A Rabi McGraw hill (1994)
Passive solar heating by J B Williams
Thermal environmental engineering PHI
IES Lighting handbook ref and application volume, IESNA

Lighting efficiency applications by Thumann 1992, Fairmont press

Semester VI	Energy management
Introduction, energy efficiency, Optimising energy efficiency in industry, Optimising energy efficiency in domestic use, Pumps, heat exchangers, condensers, Energy and environment, Energy environment interaction, environment isssues, global warming, carbon dioxide emission, deplection of ozone layer, government's regulations, energy economy interaction	
Ref: Energy management and conduction by cliveBeggs B H Elsevier Optimizing energy efficiency in the industry by Rajan , TMH Guide to Energy management by CL Capehart, Renewable energy sources and their environment impact by Abbasi and abbasi PHI Energy management handbook by Wayne C Turner. Thermodynamics by KenethWark,	