M.Tech DEGREE

(Energy Engineering)

SYLLABUS FOR
CREDIT BASED CURRICULUM

2010 – 2011
onwards

Department of Chemical Engineering

NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI – 620 015

M.Tech. Energy Engineering

The total credits required for completing the M.Tech Programme in Energy Engineering is 64

SEMESTER -1

Subject Code	Name of the Subjects	Hrs/Week			Credits
		L	T	P	
CL 701	Environmental Engineering And Pollution Control	3	0	0	3
CL 703	Fuels And Combustion Technology	3	0	0	3
CL 705	Process Modeling & Simulation in Energy Systems	2	1	0	3
CL 707	Thermal Engineering	3	0	0	3
	Elective – 1	3	0	0	3
	Elective - 2	3	0	0	3
CL 709	Environmental Engineering Laboratory	0	0	3	2
	Total				**20**

SEMESTER -2

Subject Code	Name of the Subjects	Hrs/Week			Credits
		L	T	P	
CL 702	Energy Audit And Management	2	1	0	3
CL 704	Solar Energy Engineering	3	0	0	3
CL 706	Bio Energy Engineering	3	0	0	3
	Elective –3	3	0	0	3
	Elective –4	3	0	0	3
	Elective - 5	3	0	0	3
CL 708	Solar Energy Engineering Lab	0	0	3	2
	Total				**20**

SEMESTER-3

Subject Code	Name of the Subject	Credits
CL 797	Project Work	12
	Total	**12**

SEMESTER-4

Subject Code	Name of the Subject	Credits
CL 798	Project Work	12
	Total	**12**

Elective 1 & 2

CODE	TITLE OF ELECTIVE SUBJECTS
CL 711	Waste management and energy generation technologies
CL 713	Environmental Impact Assessment and Economic Analysis
CL 715	Power sources for electric vehicles
PH 677	Instrumentation
*****	Any other Department elective

Elective 3, 4 & 5

CODE	TITLE OF ELECTIVE SUBJECTS
CL 710	Nuclear, Hydel & OTEC Power Plants
CL 712	Computational Fluid Dynamics
CL 714	Batteries and Fuel Cells
CL 716	Wind Energy Engineering
PH 608	Thin film technology and Applications
MT 671	Nuclear Materials
*****	Any other Department elective

CODE	RESERVED ELECTIVES
CL 717	Design of Heat Transfer Equipments
CL 718	Instrumentation in Energy Systems
CL 719	Computational Heat Transfer
CL 720	Power Plant Technology
CL 721	Electrical Energy Technology
CL 722	Air Conditioning and Refrigeration
CL 723	Technology Management
CL 724	Unit Operations in Industries
CL 725	Renewable Power Generation Sources
CL 726	Energy Efficient Buildings
CL 727	Optimum Utilization of Heat and Power
CL 728	Energy systems Modeling and Analysis

CL 701 ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL

Environmental Pollution- units of measurements, material balance and energy fundamentals, classification of pollution

Air Pollution Control Methods & Equipment- sources and effects of air pollution –Sampling measurement and analysis of air pollutants- Control

Solid Waste Management-Sources & Classification –Solid Waste Disposal Options - Toxic Waste Management

Water Pollution - sources of water pollutants– Classification and effects of Water Pollutants – Water pollution Laws and Standards

Environment For Comfort Living & Working - Comfort & Climate – Temperature, humidity and ventilation Control– AC load, Natural & Artificial Lighting, Noise Sources, control.

TEXT BOOKS

1. *Rao C.S. "Environmental Pollution Control Engineering," 2nd Edition, New Age International Publishers, 2006.*
2. *Gilbert M. Masters, "Introduction to Environmental Engineering and Science", 2nd Edition, Prentice Hall, 1998.*

REFERENCES:

1. *A.P. Sincero and G.A. Sincero, Environmental Engineering: A Design Approach, Prentice Hall of India Pvt. Ltd, N.Delhi.1996.*
2. *Pandey G.N and Carney G.C., "Environmental Engineering", Tata McGraw Hill Publishing Co., 1989.*
3. *Bishop P., Pollution Prevention: Fundamentals and Practice, McGraw-Hill International Edition, McGraw-Hill book Co, Singapore, 2000.*

CL 703 FUELS AND COMBUSTION TECHNOLOGY

Fuels & Fuel Analysis-Combustion Stoichiometry, theoretical & actual combustion processes –Air fuel ratio.

Combustion Thermodynamics- calculation of heat of formation & heat of combustion – First law analysis of reacting systems

Heat Treatment Furnaces- Industrial furnaces – process furnaces – Kilns – Batch & continuous furnaces

Flame, Flame Structure, Ignition and Igniters – flame propagation – deflagration – detonations- flame front – Ignition – self & forced ignition – Ignition temperature

Combustion Appliances- Gas burners- Functional requirement of burners – Gas burner Classification –Stoker firing –pulverized system of firing

TEXT BOOKS:

1. *S.P. Sharma & Chander Mohan, "Fuels & Combustion", Tata McGraw Hill Publishing Co. Ltd., 1984*
2. *Dr. Samir Sarkar, "Fuels & Combustion", Orient Longman, Second edition, 1990.*

REFERENCES:

1. *Blokh A.G, "Heat Transmission in Steam Boiler furnaces", Hemisphere Publishing Corpn. ISBN-089-116-626-2*
2. *Gupta O.P, "Elements of Fuels, Furnaces & Refractories", 3rd edition, Khanna Publishers, 1996.*
3. *Roger A. Strehlow, "Combustion Fundamentals", McGraw-Hill International editions, 1984.*
4. *Shaha A.K., "Combustion Engineering and Fuel Technology", Oxford and IBH, 1974.*
5. *Kenneth K. Kou. "Principles of Combustion", John Wiley & Sons, 2005.*

CL 705 PROCESS MODELING AND SIMULATION IN ENERGY SYSTEMS

Introduction to modeling of process systems: Systematic approach to model building, Classification of models. Conservation principles, thermodynamic principles.

Introduction to Development Based on first principles: Steady state and dynamic, Lumped and distributed parameter models, Block diagrams and computer simulation. Modeling of Process elements consisting of Mechanical (translational and rotational), Electrical, Electro-mechanical, Fluid flow, Thermal and Chemical reaction system elements.

Development of Models (Examples.): Grey box models, Empirical model building, Statistical model calibration and validation. Population balance models; Examples.

Solution strategies for Lumped parameter models: Solution methods for initial value and boundary value problems, Euler's method, R-K method, Shooting method, Finite difference methods. Solving the problems using MATLAB / *SCILAB.*

Solution strategies for Distributed parameter models: Solving parabolic, elliptic and hyperbolic partial differential equations. Finite element and Finite volume methods.

TEXT BOOKS:

1. *K. M. Hangos and I. T. Cameron, "Process Modeling and Model Analysis", Academic Press, 2001.*
2. *W. L. Luyben, "Process Modelling, Simulation and Control for Chemical Engineers", 2nd Ed., McGraw Hill Book Co., New York, 1990*
3. *Modeling and analysis of dynamic systems, by C.M .Close, D.H. Fredrick and J. C. Newell, John Wiley & Sons, 2002*
4. *W. F. Ramirez, "Computational Methods for Process Simulation", (2nd Edition) Butterworth -Heinemann, 1995.*

REFERENCES:

1. *Mark E. Davis, "Numerical Methods and Modelling for Chemical Engineers", John Wiley & Sons, 1984.*
2. *Singiresu S. Rao, "Applied Numerical Methods for Engineers and Scientists" Prentice Hall, Upper Saddle River, NJ, 2001.*

CL 707 THERMAL ENGINEERING

Air Compressor

Reciprocating air compressors. Types. Construction. Work of compression without clearance. Effect of clearance. Multistaging. Optimum intermediate pressure for perfect inter cooling. Compressor efficiencies and mean effective pressure.

Vapour and combined power cycles

Simple steam power cycle-Rankine cycle-comparison of Rankine & Carnot Cycle- reheat cycle-regenerative cycle-direct contact and surface contact regenerators- characteristics of an ideal working fluid in vapor cycle-binary vapor cycle thermodynamics of combined cycles.

Gas power cycles

Carnot cycle - Stirling cycle - Ericsson cycle - Air standard cycle - Otto cycle - Diesel Cycle-limited pressure cycle - Dual cycle - Comparison of Otto, diesel & dual cycles - Brayton cycle - Air standard cycle for jet propulsion - Brayton cycle with inter-cooling, reheating & regeneration - Second law analysis of gas power cycles.

Refrigeration cycle

Refrigerators - Heat pumps - Thee reversed Carnot cycle - Refrigeration by non-cyclic process - Reversed heat engine cycle - Ideal & actual vapor compression Refrigeration cycle-absorption refrigeration cycle - gas refrigeration cycle - Absorption refrigeration systems - Liquefaction of gases.

Steam turbines

Principles of operation - Classification of turbines - Simple impulse turbine - Velocity, Pressure compounded impulse turbine - Impulse reaction turbine velocity diagrams for flow of steam thro turbine blades - Forces on the blades & work done - Blade or diagram efficiency - Stage efficiency of reaction turbine - Degree of reaction - Steam turbine performance - Reheat factor - Descriptive examples.

Internal combustion engines

Classification of IC engine components - Four stroke cycles, valve timing - Spark ignition - Air Fuel mixtures - Mixture requirements of automotive engines - Four stroke engine - Comparison of two stroke with four stroke engines - Engine power - Indicated power - Break horse power - Engine efficiency - Performance analysis of IC engine - Heat balance - Solved problems - Cooling system of IC engines.

TEXT BOOKS:

1. *Nag. P.K., "Engineering Thermodynamics", Tata McGraw-Hill Publishing Co., Ltd., 1994.*

REFERENCES:

1. *Moran, Shapiro, Munson and Dewitt, "Introduction to Thermal Systems Engineering: Thermodynamics, Fluid Mechanics and Heat Transfer", John Wiley, N. Y 2003*
2. *Sonntag, R.E and Van Wylen, G.J.., "Fundamentals of Thermodynamics", Sixth Edition, 2003.*
3. *Bacon, D.H., "Engineering Thermodynamics ", Butterworth & Co., London, 1989.*
4. *Saad, M.A., "Thermodynamics for Engineers ", Prentice-Hall of India Pvt. Ltd., 1989.*
5. *Mayhew, A. and Rogers, B., " Engineering Thermodynamics ", Longman Green & Co. Ltd., London, E.L.B.S. 4th Edition, 1994*
6. *Ganesan, Y.*, Internal Combustion Engines, *Tata McGraw-Hill, 2003.*
7. *Heywood, J.B.*, Fundamentals of Internal Combustion Engines, *McGraw-Hill, 1988*
8. *Ballaney, P.L.*, Thermal Engineering, *Khanna Publishers, 1996.*

CL 702 ENERGY AUDIT AND MANAGEMENT

Energy Scenario - Role of Energy Managers in Industries – Energy monitoring, auditing & targeting – Economics of various Energy Conservation schemes. Total Energy Systems

Energy Audit -various Energy Conservation Measures in Steam -Losses in Boiler. Energy Conservation in Steam Systems -Case studies.

Energy conservation in Centrifugal pumps, Fans & Blowers, Air compressor – energy consumption & energy saving potentials – Design consideration.

Refrigeration & Air conditioning - Heat load estimation -Energy conservation in cooling towers & spray ponds – Case studies Electrical Energy -Energy Efficiency in Lighting – Case studies.

Organizational background desired for energy management motivation, detailed process of M&T-Thermostats, Boiler controls- proportional, differential and integral control, optimizers; compensators.

TEXT BOOKS:

1. *Eastop T.D & Croft D.R, Energy Efficiency for Engineers and Technologists, Logman Scientific & Technical, ISBN-0-582-03184, 1990.*
2. *Reay D.A, Industrial Energy Conservation, 1stedition, Pergamon Press, 1977.*

REFERNECES:

1. Larry C Whitetal, Industrial Energy Management & Utilization.

2. Power System Engineering 2nd Ed. D P Kothari, I J Nagrath, Tata McGraw-Hill Co 2008.

CL 704 SOLAR ENERGY ENGINEERING

Source of radiation – solar constant– solar charts – Measurement of diffuse, global and direct solar radiation: pyrheliometer, pyranometer, pyregeometer, net pyradiometer-sunshine recorder

Solar Non-Concentrating Collectors- Design considerations – Classification-air, liquid heating collectors –Derivation of efficiency and testing of flat plate collectors –Analysis of concentric tube collector - Solar green house.

Design – Classification– Concentrator mounting –Focusing solar concentrators-Heliostats. Solar powered absorption A/C system, water pump, chimney, drier, dehumidifier, still, cooker.

Photo-voltaic cell – characteristics- cell arrays-power electric circuits for output of solar panels-choppers-inverters-batteries-charge regulators, Construction concepts.

Energy Storage - Sensible, latent heat and thermo-chemical storage-pebble bed etc. materials for phase change-Glauber's salt-organic compounds. Solar ponds.

TEXT BOOKS:

1. D. Yogi Goswami, Frank Kreith, Jan. F. Kreider, "Principles of Solar Engineering", 2nd Edition, Taylor & Francis, 2000, Indian reprint, 2003

2. Edward E. Anderson, "Fundamentals for solar energy conversion", Addison Wesley Publ. Co., 1983.

REFERENCE S:

1. Duffie J. A and Beckman, W .A., "Solar Engineering of Thermal Process", John Wiley, 1991.

2. G. N. Tiwari and M. K. Ghosal, "Fundamentals of Renewable energy Sources", Narosa Publishing House, New Delhi, 2007

3. Energy Studies, Second Edition, by W. Shepherd and D. W. Shepherd, Imperial College Press, London, 2004

CL 706 BIO ENERGY ENGINEERING

Sources and Classification. Chemical composition, properties of biomass. Energy plantations .Size reduction, Briquetting, Drying, Storage and handling of biomass.

Feedstock for biogas, Microbial and biochemical aspects- operating parameters for biogas production. Kinetics and mechanism- High rate digesters for industrial waster water treatment.

Thermo chemical conversion of lignocelluloses biomass. Incineration, Processing for liquid fuel production. Pyrolysis -Effect of particle size, temperature, and products obtained.

Thermo chemical Principles: Effect of pressure, temperature , steam and oxygen. Fixed and fluidized bed Gasifiers- Partial gasification of biomass by CFB.

Combustion of woody biomass-Design of equipment. Cogeneration using bagasse- Case studies: Combustion of rice husk.

TEXT BOOKS:

1. *Chakraverthy A, "Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes", Oxford & IBH publishing Co, 1989.*
2. *D. Yogi Goswami, Frank Kreith, Jan. F .Kreider, "Principles of Solar Engineering", 2nd Edition, Taylor & Francis, 2000, Indian reprint, 2003 [chapter 10]*
3. *Mital K.M, "Biogas Systems: Principles and Applications", New Age International publishers (P) Ltd., 1996.*
4. *Nijaguna, B.T., Biogas Technology, New Age International publishers (P) Ltd., 2002*

REFERENCES:

1. *Venkata Ramana P and Srinivas S.N, "Biomass Energy Systems", Tata Energy Research Institute, 1996.*
2. *Rezaiyan. J and N. P. Cheremisinoff, "Gasification Technologies, A Primer for Engineers and Scientists", Taylor & Francis, 2005*
3. *Khandelwal. K. C. and Mahdi S. S, "Bio-Gas Technology", Tata McGraw-Hill Pub. Co. Ltd, 1986.*

ELECTIVES

CL 711 WASTE MANAGEMENT AND ENERGY GENERATION TECHNOLOGIES

Sources, Types, Compositions, Properties Physical, Chemical and Biological - Collection - Transfer Stations – Waste minimization and recycling of Municipal Waste.

Size Reduction - Aerobic Composting - Incineration for Medical /Pharmaceutical Waste -Environmental Impacts -Environmental Effects due to Incineration.

Land Fill Method- Types, Methods & Siting Consideration - Composition, Characteristics, generation, Control of Landfill Leachate & Gases – Environmental monitoring System for Land Fill Gases.

Sources and Nature of Hazardous Waste - Impact on Environment - Hazardous Waste -Disposal of Hazardous Waste, Underground Storage Tanks Construction, Installation & Closure

Biochemical Conversion - Industrial , Agro Residues - Anaerobic Digestion - Biogas Production - Types of Biogas Plant-Thermochemical Conversion - Gasification - Types - Briquetting - Industrial Applications of Gasifiers - Environment Benefits

TEXT BOOK:

1. *Shah, Kanti L., Basics of Solid & Hazardous Waste Management Technology, Printice Hall, 2000*

REFERENCES:

1. Parker, Colin, & Roberts, Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985

CL 713 ENVIRONMENTAL IMPACT ASSESSMENT AND ECONOMIC ANALYSIS

Principles, Production and assessment of impacts due to air and water pollution on the environment. Environment Impact Assessment in the land and biological environment

Methodologies for Environmental Impact Assessment – Case studies

Assessing Impacts and Setting Priorities – Economic Measurement of Environmental Impacts – Theoretical Basis and Practical Applications.

Selectively Applicable Techniques of Valuing Environmental Impacts – Potentially Applicable Techniques of Valuing Environmental Impacts.

Maximum Credible Accident - Rapid Environmental Impact Assessment - The limits of Economic Measurement of Environmental Impacts – case studies

TEXT BOOK:

1. Barthwal, R. R., Environmental Impact Assessment, New Age International publishers (P) Ltd., 2002

2. Adaptive environmental assessment and Management Ed. C. S. Holling, John Wiley and Sons, 2000

3. Renewable Energy Sources and Their Environmental Impact, S.A. Abbasi and N. Abbasi, Prentice Hall of India, N. Delhi 2006

REFERENCES:

1. Environmental Impact Assessment L.W .Canter, McGraw Hill Book Company, 1977.

CL 715 POWER SOURCES FOR ELECTRIC VEHICLES

The Electric Vehicle Debate, Primary Energy Sources and Alternative Fuels for Transportation, History of Electric Vehicles, Electrochemical Power Sources – Secondary Batteries and Fuel Cells

Sources- Aqueous Electrolyte Batteries –Lead Acid, Nickel – Iron, Nickel – Zinc, Metal – Air Zinc – Halogen

Non Aqueous Electrolyte Batteries- High Temperature Batteries, Organo Electrolyte and Solid State Batteries

Overview of Performances of Candidate Secondary Battery Systems-Fuel Cells - Acid Systems, Direct Methanol / Air Systems ,Alkaline Systems-Overview of Performances of candidate Fuel Cell Systems, Battery / Fuel cell / Internal

Combustion Engine Hybrid Electric Vehicles, Laboratory Test of Electric Vehicle Batteries, Vehicle tests with Electric Vehicle Batteries, Future of Electric Vehicles

TEXT BOOK:

1. Power Sources for Electric Vehicles, Edited by B.D. McNicol and D.A.J. Rand, Elsevier Publications.1998

2. Lithium Batteries for Hybrid Cars By John Voelcker, IEEE Spectrum, 1990

REFERENCES:

1. Hand Book of Batteries and Fuel cells, 3rd Edition, Edited by David Linden and Thomas. B. Reddy, McGraw Hill Book Company, N.Y. 2002.

2.Fuel Cells, Principles and Applications, Viswanathan, B. and Scibioh, Aulice M, Universities Press, 2006.

3.The Essential Hybrid Car Handbook: A Buyer's Guide (Paperback) by Nick Yost, The Lyons Press, N.Y. 2006.

PH 677 – INSTRUMENTATION

Errors in observations and treatment of experimental data – estimation of errors – theory of errors and distribution laws – least squares method: curve fitting, statistical assessment of goodness of fit.

Production and measurement of high vacuum – principles and operation of various pumps and gauges – design of high vacuum systems - high pressure cells and measurements at high pressures.

Production and measurement of low temperatures – Design of cryostats – High temperature furnaces: resistance, induction and arc furnaces – measurement of high temperatures.

Optical monochromators, filters and spectrophotometers for UV, visible and infrared. Measurement of reflectivity, absorption and fluorescence. Radiation detectors: pyroelectric, ferroelectric, thermoelectric, photoconducting, photoelectric and photomultiplier, scintillation types of detectors, circuits, sensitivity and spectral response, photon counters.

Magnetic resonance techniques: NOR, ESR, NMR, ENDOR – principles and schematic working systems – measurement of high and low electrical resistivity – d.c. and a.c. four probe technique – Impedance considerations and accuracy – Signal processing and signal averaging – Time domain measurements Box car integrator – Computer data processing, programming languages.

REFERENCES:

1. *C.S. Rangan, G.R. Sharma and V.S.V. Mani, Instrumentation Devices and Systems, Tata McGraw-Hill, 1983.*
2. *H.H. Willard, L.L. Merrit and John A. Dean, Instrumental Methods of Analysis, 6th edition, CBS Publishers & Distributors, 1986.*
3. *Barry E. Jones, Instrumentation Measurement and Feedback, Tata McGraw-Hill,1978.*
4. *J.F. Rabek, Experimental Methods in Photochemistry and Photophysics, Parts 1 and 2, John Wiley, 1982.*

CL 710 NUCLEAR, HYDEL & OTEC POWER PLANTS

Nuclear Power–Radioactivity & Radioactive charge, Types of reaction – General problem of reactor operation.

Current Generation power reactors- Pressurized water reactors – Boiling water reactors – Gas-cooled reactors – Advanced Design

Hydrology & Hydro - Electric Power Plants- Hydrographs – Flow duration curve – Mass curve & storage. Site selection for hydroelectric power plants.

Design Construction & Operation Of Hydro-Electric Power Plants- Components –Advantages & Disadvantage of under ground power station

Ocean Thermal Energy conversion -Operational problem – Ecological & environmental impacts. Water power – Tidal power – wave power – geothermal power

TEXT BOOKS:

1. *Black and Veatch, "Power Plant Engineering", ISBN 0-412-06401-4, CBS Publishers and Distributors, Chapter 23424.*
2 *S .Rao & Dr .B. B. Parulekar, "Energy Technology", Third Edition, Khanna Publishers.*

REFERENCES:

1. Samuel Glasstone and Alexander Sesonske "Nuclear Reactor Engineering" Third Edition.

CL 712 COMPUTATIONAL FLUID DYNAMICS

Governing Equations of Fluid Flow, Finite Difference, Finite Volume, Finite Element Methods, Laplace Equation, Diffusion Equation or Wave Equation

Application of Finite Volume Method to Fluid Flow problems - Pressure Correction Techniques-Gauss Siedel, Gauss Jordan. Introduction to Multi grid Methods. Boundary Conditions

Structured and Unstructured Mesh- Introduction to CAD systems and Different Standards used for DATA Exchange.

Governing Equations for Turbulent Flow, Rotating Machinery, Combusting Flow, Multiphase Flow.

Simple Internal Flows: T-Junction, Driven Cavity, Manifold, Valves, External Flows: Flow Over Ahmed Body, Car-Reacting Flow in a Gas Burner, Multiphase Flow in an Air Lift Reactor.

TEXT BOOKS:

1. H.K. Versteeg & W. Malalasekera, "An Introduction to Computational Fluid Dynamics - The finite volume approach" Longman, 1995

2. Segerlind .L. J., "Applied finite Element Analysis", 2nd edition, John Wiley, 1984

REFERENCES:

1. Anderson, "Computational Fluid Dynamics" McGraw Hill Company, 1995

2. D.A. Caughey and M.M.Hafez, "Frontiers of Computational Fluid Dynamics 1994" John Wiley & Sons, 1994

CL 714 BATTERIES & FUEL CELLS

Battery -Storage Cell Technologies-Storage cell fundamentals- Characteristics-Emerging trends in batteries.

Specifications - Storage cell definitions & specifications, Carbon-zinc & alkaline cells, Mercury, zinc-air, & silver oxide button cells, Lead –acid, Edison, Nicad & Nimh cells, Lithium technology,

Applications- Storage cell summary, Applications of storage cell- Industrial

Fuel cell fundamentals, The alkaline fuel cell, Acidic fuel cells, SOFC-Emerging areas in Fuel cells

Fuel cell outlook, Sources, comments, & revision history, Applications – Industrial and commercial

TEXT BOOKS:

1. *Hand Book of Batteries and Fuel cells, 3rd Edition, Edited by David Linden and Thomas. B. Reddy, McGraw Hill Book Company, N.Y. 2002*
2. *Principles of Fuel Cells, by Xianguo Li, Taylor & Francis, 2006*
3. *Fuel Cells, Principles and Applications, Viswanathan, B. and Scibioh, Aulice M, Universities Press, 2006*

CL 716 WIND ENERGY ENGINEERING

Measurement and instrumentation – Beau fort number -Gust parameters – wind type – power law index -Betz constant -Terrain value.

Energy in wind– study of wind applicable Indian standards – Steel Tables, Structural Engineering.

Variables in wind energy conversion systems – wind power density – power in a wind stream – wind turbine efficiency – Forces on the blades of a propeller – Solidity and selection curves.

HAWT, VAWT– tower design-power duration curves- wind rose diagrams-study of characteristics- actuator theory- controls and instrumentations.

Grid-combination of diesel generator, Battery storage – wind turbine circuits-Wind farms— fatigue stress.

TEXT BOOKS:

1. *S. Rao & B. B. Parulekar, "Energy Technology", 4th edition, Khanna publishers, 2005.*
2. *Wind energy Handbook, Edited by T. Burton, D. Sharpe, N. Jenkins and E. Bossanyi, John Wiley & Sons, 2001*
3. *Wind and Solar Power Systems, Mukund. R. Patel, 2nd Edition, Taylor & Francis, 2001*
4. *L .L. Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.*
5. *D.A. Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press*

REFERENCES:

1. *Anna Mani & Nooley, "Wind Energy Data for India", 1983.*
2. *IS 875 Part IV and IS 1893 semics D+STDS mareials STDS IS 226 (IS 2862, ASTMS 36, BS 4360 GR 43D and A).*
3. *Logan (EARL), "Turbo Machinery Basic theory and applications", 1981.*

PH 608 THIN FILM TECHNOLOGY AND APPLICATIONS

Preparation of Thin-films Kinetic aspects of Gases in a vacuum chamber - Classifications of vacuum ranges Production of vacuum - Pressure measurement in vacuum systems - Physical vapour deposition - Evaporation Techniques - Sputtering (RF & DC) - Pulsed Laser deposition- Liquid Phase Epitaxy- Vapour Phase Epitaxy- Molecular Beam Epitaxy.

Film growth and measurement of thickness Thermodynamics and Kinetics of thin film formation - Film growth – five stages - In corporation of defects and impurities in films - Deposition parameters and grain size - structure of thin films - Microbalance technique - quartz crystal monitor photometric - Ellipsometry and interferometers - Measurement of rate of deposition using ratemeter - cleaning of substrate.

Characterization X-ray Diffraction(XRD) - SEM, Photoluminescence(PL) - Raman Sepectroscopy, UV-Vis-IR Spectrophotometer – AFM - Hall effect – SIMS - X-ray Photoemission Spectroscopy (XPS) - Vibrational Sample Magnetometers, Rutherford Back Scattering (RBS).

Properties of thin films Dielectric properties - Experimental techniques for dielectric film - annealing effect, effect of film thickness on dielectric properties – determination of optical constants – Experimental techniques for determination of optical parameters - Magnetic and mechanical properties - Hall effect compilations - Adhesion, stress, strength, Raleigh surface waves - Ferromagnetic properties of Thin films - Experimental methods for measurement of mechanical properties of thin films.

Applications Micro and optoelectronic devices, quantum dots, Data storage, corrosion and wear coatings - Polymer films, MEMS, optical applications - Applications in electronics – electric contacts, connections and resistors, capacitors and inductances - Applications of ferromagnetic and super conducting films - active electronic elements, micro acoustic elements using surface waves - integrated circuits - thin films in optoelectronics and integrated optics.

REFERENCES:

1. *K.L.Chopra, "Thin film phenomena", Mc-Graw Hill Book company, New york, 1969.*
2. *Ludminla Eckertova, "Physics of thin films", Plenum press, New york, 1977.*
3. *A. Goswami, "Thin film fundamentals", New age international (P) Ltd. Publishers, New Delhi, 1996.*

MT 671 NUCLEAR MATERIALS

Introduction to nuclear energy / reactors – comparison of different modes of energy generation – ecological and environmental aspects

Nuclear reactions – concept of half life, nuclear minerals – related exploration and processing

Material requirements – structural materials, coolants, shielding materials and fuel rods – fabrication requirements

Nuclear irradiation effects on structural materials – safe guards, safety and health protection

Strategic issues – current status and major needs, overview of nuclear scenario in India, nuclear scenario at international level.

TEXT BOOKS:

1. *Benjamin M. M., Van Nostrand "Nuclear Reactor Materials and Applications", Reinhold Company Inc, 1983.*
2. *Henley E.J., & Herbert Kouts, "Advances in Nuclear Science and Technology".*

CL 717 DESIGN OF HEAT TRANSFER EQUIPMENTS

Types – Details –Specifications for heat exchangers – Standards of heat exchangers

Study of different methods used for design of heat exchangers, classification, design methodology, LMTD and NTU methods.

Design of double pipe heat exchanger-study and performance- Design of shell and tube heat exchanger.

Extended surfaces, fin design, longitudinal and transverse fins.

Regenerators - Plate type heat exchangers - Compact heat exchangers- Cross flow heat exchangers

TEXT BOOKS:

1. D. G. Kern: "Process Heat Transfer," McGraw-Hill Book Co., N.Y. 1997.

2. W.L.McCabe, J.C. Smith, P. Harriott, "Unit Operations of Chemical Engineering Sixth Edition, McGraw Hill Company, 2001.

3. M. Necati Ozisik "Heat Transfer A Basic Approach", International Edition, McGraw-Hill Company, 1985.

REFERENCES:

1. *S. Kokac, "Heat Exchangers-Thermal Hydraulic Fundamentals and Design", McGraw Hill, 1985.*
2. *J .P. Gupta, "Heat Exchanger Design II",C. S. Enterprises,1979.*
3. *A Heat Transfer Textbook, by J.H. Lienhard IV and J.H. Lienhard V, Phlogiston Press, Cambridge, Massachusetts, 2005.*

CL 718 INSTRUMENTATION IN ENERGY SYSTEMS

Measurement Errors - Materials, radiant storage- Transducer classification- Static and dynamic characteristics of transducers, Transient analysis of a control system.

Temperature Measurement - Bimaterials, Pressure thermometers, Thermocouples, RTD, Thermisters, and Pyrometry, pyrometers- Calibration of Pressure measuring equipment.

Flow Measurement- Variable head flow meters- Rota meters, Electromagnetic flow meters, Hot wire anemometers, Hot film transducers, Ultrasonic flow meters.

Air pollution and Miscellaneous Measurements- Particulate sampling techniques, SO_2, Combustion Products, Opacity , odour measurements - Measurement of liquid level, Humidity, O_2, CO_2 in flue gases- pH measurement

Moving Iron/coil, Energy measurement, power factor meter-Analog signal conditioning, Amplifiers, Instrumentation amplifier, A/D and D/A converters, Digital data processing and Data acquisition system.

TEXT BOOKS:

1. *A. K. Sawhney. Puneet Sawney: A course in Mechanical Measurements and Instrumentation. Dhanpat Rai & Co 2002*
2. *Bechwith. Marangoni. Lienhard: Mechanical Measurements Fifth edition. Addison-Wesley 2000*

REFERENCES:

1. J.P. Holman: Experimental methods for engineers Sixth edition, McGraw-Hill .1994.

CL 719 COMPUTATIONAL HEAT TRANSFER

Physical Phenomena Governing Differential Equation - Energy Equation - Momentum Equation - Nature of Co-ordinates -Discretization Methods

Parabolic Equations - Explicit, Implicit and Crank Nicholson Methods. Cartesian and PolarCo-ordinates - Mixed Boundary Condition -Jacobi - Gauss-siedel and SOR Methods.

Heat Condition And Convection Control Volume Approach - Steady and Unsteady One Dimensional Conduction - Two and Three Dimensional -Power Law Scheme - Simpler Algorithm.

General Applicability of the Method - Approximate Analytical Solution - Raleigh's Method. Galerikin Method, Solution Methods.

Isoparametric Element Formulations Conduction and Diffusion Equations - Heat Transfer Packages - Heat 2, HEATAX, RADIAT, ANSYS

TEXT BOOKS:

1. *Suhas V.Patnakar, Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, 1980*
2. *Jaluria and Torrance, Computational Heat Transfer - Hemisphere Publishing Corporation, 1986*

REFERENCES:

1. *A. R. Mitchell and D.F. Grifths, Finite Difference Method in Partial Differential Equations, John Wiley & Sons, 1980*

CL 720 POWER PLANT TECHNOLOGY

Power Plants - Features, Components and Layouts - Working of Power Plants, Power Plant Economics

Boiler Classification - Boiler Types - Fire Tube & Water Tube Boilers - Fluidized Bed Boilers - Positive Circulation Boilers - Thermal Liquid Heaters & Vaporizers

Classification - Features - Working - Performance of Steam Turbines - Losses in Steam Turbines - Trouble Shooting

Classification and Comparison of Different Types Gas Turbine Power Plants Components - Economics & Future of Combined Cycles

Integrated Gasification Combined Cycle (IGCC) – Indirect Fired Combined Cycle (IFCC) – Magneto Hydrodynamics (MHD) – Fuel Cells – Micro turbines– RDF based power plants.

TEXT BOOK:

1. *Thomas C. Elliott ,"Standard Hand Book of Power Plant Engineering"*

REFERENCES:

1. *E L Wakil, "Power Plant Engineering", McGraw-hill Book Co, N.Y. 2001*
2. *Arora and Domkundwar, A course in Power Plant Engineering, Dhanpat Ra, N. Delhi. 2003*
3. *Nag, P.K., "Power Plant Engineering", 2nd Edition, TMH, 2001*

CL 721 ELECTRICAL ENERGY TECHNOLOGY

Transformers – Parallel operation, auto transformers DC machines - generator characteristics - motor characteristics – applications Synchronous machines - permanent magnet alternators – Induction machines.

Transmission line – power flow study – power factor improvement, faults on power systems, symmetrical components, introduction to HVDC systems.

Controlled rectifiers, choppers, inverters, voltage regulators and cyclo converters.

Speed control of dc motors – converter –fed and chopper –fed control. Speed control of ac motors – Inverter –fed and ac voltage controller –fed schemes.

Wind-driven induction generators, grid connected Photo-voltaic systems, Steady state performance, integration issues, principles of energy auditing.

TEXT BOOKS:

1. *John F. Walker and Jenkins N., "Wind energy technology", John Wiley and sons, Chichester U.K, 1997*
2. *Syed A Nasar, "Electric energy conversion and transmission', Macmillan Publishing company, New York, 1985*

REFERENCES:

1. *Sen P.C. "Power Electronics", NBT Code no (45-36/1980), Tata Mc Graw –Hill Publishing company, 1993.*
2. *John J. Graigner and W.D. Stevenson, "Power system analysis", McGraw-Hill publishing company, 1994.*

CL 722 AIR CONDITIONING AND REFRIGERATION

Thermodynamic concepts, psychometric; principles of air conditioning, methods of refrigeration.

Vapour compression system adsorption and adsorption cycles, Air-cycle steam jet.

Refrigeration systems and their performances: compressors, expansion devices, evaporators, condensers, absorbers, Cooling towers etc.

Comfort factors-specifications –Limits for humidity, temperature etc
Heat load estimation, air distribution, ventilation, instrumentation.

TEXT BOOKS:

1. *Stoecker W.F. "Refrigeration and Air Conditioning", TMH edition, McGraw Hill publication, (1980)*
2. *Ballaney P.L. "Refrigeration and Air Conditioning" V Ed. Khanna Publishers (1980)*

REFERENCES:

1. *Trott A.R." Refrigeration and Air Conditioning" 2nd Ed. Butterworth Publishers.1980*

CL 723 TECHNOLOGY MANAGEMENT

PASTER program aimed at technological self-reliance-– Strategy Evaluation & Correction, Strategy Implementation - Business Ethics, Knowledge Management, Bench Marking.

Invention, Innovation, Industrial & IPR, Patents, Copyrights, Trademarks, Design Registration, Trade Secrets, WTO, Trade, Patent Specifications, Patent Search Websites.

Technology Transfer Model, Technology Search Strategy, Dimensions of Technology Transfer, Features of Technology Package, Routes of Technology Transfer,

Techno market Survey, Technology Evaluation Parameters, Identification of Core Competence- Constraints in Technology Absorption, Importance of Diffusion

Exploratory Method of TF – Delphy Technique, Cross Impact Matrix, Curve Fitting, Morphological Methods, Trend Extrapolation, Regression Analysis

TEXT BOOKS:

1. Wright, Peter, Kroll, Mark J. and Parnell, John A: Strategic Management Concepts and Cases, Prentice – Hall, N. J. 1996.

2. Coates, V.T.:"A Handbook of Technology Assessment", U.S. Department of Energy, Washington D.C., 1988.

3. Ayres, Robert U: "Technologies forecasting and Long Range planning".

REFERENCES:

1. Intellectual Property Protection in India: A Practical Guide for Scientists, Technologies and Other Users, Delhi, TIFAC / CSIR, 1993.

2. H. Ansoff "Implementing Strategic Management" by Englewood Cliffs, New Jersey.

3 .Michael E. Porter, "Corporate Strategy"– New York Free Press.

CL 724 UNIT OPERATIONS IN INDUSTRIES

Crushing, Grinding Size Separation & Conveying Of Bulk Solids Various Laws of Crushing - Classification of Crushing and Grinding Machineries -

Mixing of Liquids / Liquids, Liquids / Gases, Liquids / Solids - Types of Mixers - Industrial Filtration

Evaporator- Duhrings Chart - Boiling Point Elevation - Capacity and Economy of Evaporators - Evaporators Classification – Economy and capacity

Humidity Chart - Wet bulb Temperature and Measurement of Humidity Equilibrium Moisture Content - Bound, Unbound, Free Moisture - Drying Rate Curves Classification of Dryers

Distillation Methods - Minimum Reflux Ratio - Total Reflux - Optimum Reflux Ratio - Steam Distillation Calculations, Concepts of Azeotropic and Extractive Distillation –

TEXT BOOKS:

1. *P Chattopadhyay, "Unit operations of Chemical Engineering", 2nd edition, Khanna Publishers, 1996.*
2. *W. L. McCabe and J.C. Smith and P. Harriot, "Unit operations of Chemical Engineering", 6th edition, McGraw Hill International editions, 2001.*

REFERENCES:

1. *Alan S Foust, "Principles of Unit Operations", Second Edition, Wiley International Edition, 1960.*
2. *J.M. Coulson & Richardson, Chemical Engineering,, 5th edition, Butterworth Heinemann, 1996.*

CL 725 RENEWABLE POWER GENERATION SOURCES

Basic characteristics of sunlight – solar energy source- photovoltaic eeH-characteristics –equivalent circuit – photo voltaic for battery charging – charge regulators

Source –energy in the wind- aerodynamics – rotor types – forces developed by blades- braking systems - control and monitoring system – power performance

Wind driven induction generators– steady state performance – modeling – integration issues-impact on central generation-transmission and distribution systems.

Wind – diesel system– permanent magnet alternators-modeling- steady state equivalent circuit-self – excited induction generators-integrated wind – solar systems.

Micro-hydel electric systems- isolated and parallel operation of generators-geothermal operation of generators – geothermal – tidal and OTEC systems.

TEXT BOOKS:

1. *John F. Walker & Jenkins. N., "Wind Energy Technology", John Wiley and sons, Chichester, 1997.*
2. *Van Overstraeton. R. J. and Mertens R. P., "Physics Technology and use of Photovoltaic" Adam Higher, Bristol, 1996.*

REFERENCES:

1. *Freris LL, "Wind Energy Conversion Systems", Prentice Hall, U.K., 1990.*
2. *Imamura M S .et.al "Photovoltaic System Technology. European hand book" H. S. Stephen & Associates.1992*

CL 726 ENERGY EFFICIENT BUILDINGS

Architecture- Building Science and its significance. Indoor Environment. Components of Indoor Environment. Quality of Indoor Environment.

Human Comfort-Thermal, Visual, Acoustical and Olfactory comfort. Concept of Sol-air temperature and its significance. Ventilation and is significance.

Cooling and heating concepts, Passive concepts appropriate for the various climatic zones in India. Classification of building materials based on energy intensity.

Energy Management of Buildings and Energy Audit of Buildings. - Energy management matrix monitoring and targeting.

Energy Efficient Landscape Design -Modification of microclimate through landscape elements for energy conservation.

TEXT BOOKS:

1. *Sodha M.,Bansal, N.K., Bansal,P.K., Kumar, A.. and Malik, M.A.S.,"Solar Passive Buildings", Pergamon Press, 1986.*
2. *Koenigsberger, O.H., Ingersoll, T.G., Mayhew Alan and Szokolay, S. V., "Manual of Tropical Housing and Building part 1: Climatic Design", OLBN 0 00212 0011,Orient Longman Limited, 1973.*

REFERENCES:

1. *Bureau of Indian Standards, I.S. 11907 –1986 Recommendations for calculation of Solar Radiation Buildings, 1986.*
2. *Givoni,B., "Man, Climate and Architecture", Elsevier, Amsterdam, 1986.*
3. *Smith, R. J., Phillips, G.M. and Sweeney, M. "Environmental Science", Longman Scientific and Technical, Essex, 1982.*

CL 727 OPTIMUM UTILIZATION OF HEAT AND POWER

Basic concepts of CHP- The benefits and problems with CHP -Balance of energy demand– Types of prime movers –Economics– CHP in various sectors

Pinch Technology–significance– Selection of pinch temperature difference – Stream splitting – Process retrofit – Installation of heat pumps, heat engines - Grand composite curve.

Insulation – Recuperative heat exchanger – Run –around coil systems – Regenerative heat exchangers – Heat pumps – Heat pipes –. Waste Heat Recovery -Cogeneration Technology

Sources of waste heat, Cogeneration - Principles of Thermodynamics - Combined Cycles-Topping -Bottoming - Organic Rankine Cycles- Advantages of Cogeneration Technology

Application & techno economics of Cogeneration- Cogeneration - Performance calculations, Part load characteristics- financial considerations - Operating and Investments

TEXT BOOKS:

1. *Eastop, T.D. & Croft D.R, "Energy efficiency for engineers and Technologists", 2nd edition, Longman Harlow, 1990.*
2. *O'Callaghan, Paul W, "Design and Management for energy conservation", Pergamon, 1993.*

REFERENCES:

1. *Osborn, peter D, "Handbook of energy data and calculations including directory of products and services", Butterworths, 1980.*
2. *Charles H.Butler, Cogeneration, McGraw Hill Book Co., 1984.*
3. *Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford, 1987*

CL 728 ENERGY SYSTEMS MODELLING AND ANALYSIS

Overview of technologies and conventional methods of energy conversion, Workable and optimum systems, Steps in arriving at a workable system, Creativity in concept selection

Mathematical modeling, Exponential forms- Method of least squares - Counter flow heat exchanger, Evaporators and Condensers, Effectiveness, NTU, Pressure drop and pumping power

Classes of simulation, flow diagrams, Sequential and simultaneous calculations, Newton-Raphson method- Optimization procedure, mathematical statement of the problem

The Lagrange multiplier equations, Sensitivity coefficients- Single variable – Exhaustive, Dichotomous and Fibonacci, Multivariable unconstrained - Lattice, Univariable and Steepest ascent

Dynamic Programming-Geometric Programming-Linear Programming- Linear regression analysis, Internal energy and enthalpy, Pressure temperature relationship at saturated conditions

TEXT BOOKS:

1. *W.F. Stoecker: "Design of Thermal Systems", 3rd Ed., McGraw Hill,1989.*
2. *B.K.Hodge: "Analysis and Design of Thermal Systems", Prentice Hall Inc., 1990.*

REFERENCES:

1. *I. J. Nagrath & M .Gopal: "Systems Modelling and Analysis", Tata McGraw Hill.*
2. *D.J. Wide: "Globally Optimal Design", Wiley- Interscience, 1978.*

CL 709 ENVIRONMENTAL ENGINEERING LABORATORY

1. Pollutant analysis using orsat apparatus
2. Air pollution analysis using flue gas analyzer
3. Measurement of COD for liquid effluents
4. Settling studies
5. Study of aerator design on water treatment
6. Study on noise pollution of various devices
7. Gas absorption using foam bed
8. Hydrocylones for removing suspended particles
9. Cyclones to remove dust particles

CL 708 SOLAR ENERGY ENGINEERING LABORATORY

1. Study of direct and diffused beam solar radiation
2. Study of green house effect
3. Performance evaluation of solar flat plate collector
4. Study the effect of solar flat plate collector in parallel combination
5. Performance evaluation of concentrating solar collector
6. Performance evaluation of solar cooker
7. Performance evaluation of a solar PV panel
8. Performance of PV panel in series and parallel combination
9. Charging characteristics of a battery using PV panel
10. Effect of tilt angle on solar PV panel
11. Effect of shadow on solar PV panel
12. Effect of surrounding temperature on PV panel
13. Performance evaluation of solar funnel

COMPUTATIONAL FLUID DYNAMICS LABORATORY

1. Flow in static mixer
2. Flow in a process injection-mixing pipe
3. Flow from a circular vent
4. Flow in an Axial rotor /stator arrangement
5. Multiphase flow in mixing vessel
6. External flow over Ahmed body
7. Supersonic flow in a Laval nozzle
8. Flow through a butterfly valve
9. Flow through an automatic catalytic converter
10. Flow through an engine inlet valve
11. Conjugate heat transfer in a process-heating coil
12. Combustion and radiation in a Can Combustor