FACULTY OF ENGINEERING

Structure and syllabus of M.E. (Mechanical) (Energy Engineering) (w.e.f. 2012-2013)

UNIVERSITY OF PUNE
Ganeshkhind, Pune - 07

M.E. Mechanical (Energy Engineering)
(w. e. f. June 2012)

Subject Code	Subject	Teaching Scheme		Examination Scheme				Credits
		Lecture	Practical	Paper	TW	OR	Total	
Semester I								
502501	Advanced Engineering Mathematics	03	---	100	---	---	100	03
502502	Advanced Thermodynamics	03	---	100	---	---	100	03
502503	Energy Conversion Systems	03	---	100	---	---	100	03
502504	Elective – I	03	---	100	---	---	100	03
502505	Elective – II	03	---	100	---	---	100	03
502506	Lab Practice – I	---	06	---	50	---	50	03
502507	Seminar – I	---	04	---	50	---	50	02
	Total	**15**	**10**	**500**	**100**	**---**	**600**	**20**
Semester II								
502508	Convective Heat Transfer	03	---	100	---	---	100	03
502509	Energy Systems Modeling and Analysis	03	---	100	---	---	100	03
502510	Energy Management	03	---	100	---	---	100	03
502511	Elective III	03	---	100	---	---	100	03
502512	Elective IV	03	---	100	---	---	100	03
502513	Lab. Practice – II	---	06	---	50	---	50	03
502514	Seminar – II	---	04	---	50	---	50	02
	Total	**15**	**10**	**500**	**100**	**---**	**600**	**20**
Semester III								
602515	Seminar – III	---	04	---	50	---	50	02
602516	Project Stage – I	---	18	---	50	---	50	06
	Total	**---**	**22**	**---**	**100**	**---**	**100**	**08**
Semester IV								
602517	Project Stage – II	---	18	---	150	50	200	12
	Total	**---**	**18**	**---**	**150**	**50**	**200**	**12**
	Grand Total	**30**	**60**	**1000**	**450**	**50**	**1500**	**60**

- The term work of project stage II of semester IV should be assessed jointly by the pair of internal and external examiners, along with oral examination of the same.

Note- The Contact Hours for the calculation of load of teacher:
Seminar- 1 Hr. / week / student
Project - 2 Hrs. / week / student

Elective – I

CODE	Subject
502504 A	Nuclear Materials and Reactor Fundamentals
502504 B	Process Optimization
502504 C	Plant Operation, Dynamics and Control

Elective – II

CODE	Subject
502505 A	Electromechanical and Reactor Systems
502505 B	Process Integration
502505 C	Non Conventional Energy Sources

Elective – III

CODE	Subject
502511 A	Radiation Safety and Shielding
502511 B	Energy and Climate
502511 C	Energy Regulatory Frameworks

Elective – IV

CODE	Subject
502512 A	Nuclear Measurement and Detection.
502512 B	Energy Resources and Economics
502512 C	Processing Storage and Disposal of Nuclear Waste
502512 D	Open Elective

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502501 - Advanced Engineering Mathematics

Teaching Scheme:
Lecture: 3 Hrs. / Week

Examination
Paper: 100 Marks
Paper Duration: 3 Hrs.

Units-I

- Ordinary Differential Equations (O.D.E.)
- Power series solutions of differential equations. Frobenius method

Unit-II

- Legendre polynomials and Bessel functions
- O.D.E. with boundary conditions, Sturm-Liouville theory and eigen function expansions

Unit-III

- P.D.E. in polar and spherical coordinates
- Classification, Formulation and method of solution of wave equation, D'Alembert's solution to wave equation
- Non-homogeneous heat equation and Laplace's equation

Unit-IV

- Fourier series and Fourier integral transform
- Fourier series solution of the heat and wave equations (1-dimensional)

Unit-V

- Linear Transformations and Coordinate transformations

Unit-VI

- Fundamental Operations with tensor, covariant, contravariant and mixed tensors.

Assignments/ Lab work (Any Four):

1. Assignment on ODE
2. Assignment on Rodrigues Formula Bessel Function of First Kind
3. Assignments on wave, heat and Laplace equations
4. Assignment on Fourier series and Fourier integral transform
5. Assignment on Linear Transformations
6. Assignment on tensor analysis

References:

1. Ian Sneddon, Elements of Partial Differential Equations, McGraw Hill International, 1985.
2. Shepley L Ross, Differential Equations, John Wiley & Sons, Third Edition, 2004.
3. L.A. Pipes and L.R. Harwill: Applied Mathematics for Engineers and Physicists, Mc Graw Hill, 1971.
4. Erwin Kreyzig, Advanced Engineering Mathematics Edition 9, John Wiley & Sons

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502502 - Advanced Thermodynamics

Teaching Scheme:
Lecture: 3 Hrs./ Week

Examination
Paper: 100 Marks
Paper Duration: 3 Hrs.

Unit I: Equation of State
State postulate for Simple System and equation of state, Ideal gas equation, Deviation from ideal gas, Equation of state for real gases, generalized Compressibility chart, Law of corresponding states

Unit II: Properties of Pure Substances
Phase change process of pure substances, PVT surface, P-V and P- T diagrams, Use of steam tables and charts in common use.

Unit III: Laws of thermodynamics, 2nd law Analysis for Engg. Systems, Entropy flow & entropy generation, Increase of entropy principle, entropy change of pure sub, T-ds relations, entropy generation, thermo electricity, Onsager equation, Exergy analysis of thermal systems, decrease of Exergy principle and Exergy destruction

Unit IV: Thermodynamic Property Relations
Partial Differentials, Maxwell relations, Clapeyron equation, general relations for du, dh, ds, and Cv and Cp, Joule Thomson Coefficient, h, u, s of real gases.

Unit V: Chemical Thermodynamics
Chemical reaction - Fuels and combustion, Enthalpy of formation and enthalpy of combustion, First law analysis of reacting systems, adiabatic flame temperature Chemical and Phase equilibrium - Criterion for chemical equilibrium, equilibrium constant for ideal gas mixtures, some remarks about Kp of Ideal-gas mixtures, fugacity and activity, Simultaneous relations, Variation of Kp with Temperature, Phase equilibrium, Gibb’s phase rule, Third law of thermodynamics, Nerst heat theorem and heat death of universe

Unit VI: Gas Mixtures and Statistical Thermodynamics – Mass & mole fractions, Dalton’s law of partial pressure, Amagat’s law, Kay’s rule.
Fundamentals, equilibrium distribution, Significance of Lagrangian multipliers, Partition function for Canonical Ensemble, partition function for an ideal monatomic gas, equipartition of energy, Bose Einstein statistics, Fermi-Dirac statistics,

Exercises/ Assignments for laboratory Practice (Any four):

1. Computer aided energy analysis of steady flow cyclic system.
2. Study of mixture of gases, gas and vapour, estimation of properties and preparation of charts.
3. Analysis of ideal gas system using statistical thermodynamic techniques.

4. Study of behavior of pure substance with change in pressure and temperature.
5. Preparation of computer program to study the effect of percentage of theoretical on adiabatic flame temperature and equilibrium composition for a hydrocarbon fuel. (Program to be run for variable input data.)
6 To find the calorific value of fuels (Solid/ liquid/ gaseous)

References:

1. Bejan, Advanced Thermodynamics, John Wiley, Inc.
2. Van Wylen & Sontag: thermodynamics, John Wiley & Sons, Inc., USA
3. Howell & Dedcius: Fundamentals of engineering Thermodynamics, McGraw Hill, Inc, USA
4. Holman, Thermodynamics, 4th edition, McGraw Hill
5. Zimmansky & Dittman, Heat and Thermodynamics, 7th edition, TMH
6. Jones and Hawkings: engineering Thermodynamics, john Wiley & Sons, Inc.USA
7. Wark, Advanced Thermodynamics, McGraw Hill
8. Nag P.K., Basic & Applied Thermodynamics, TMH, New Delhi.
9. Jones & Dugan, Advanced Thermodynamics, Prentice Hall Int.
10. Cengel, Thermodynamics, TMH
11. M. M. El-Wakil: Power Plant Technology, McGraw Hill, 1985
12. A. W. Culp Jr: Principles of Energy Conversion, McGraw Hill, 2001
13. H. A. Sorensen: Energy Conversion Systems, J. Wiley, 1983

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502503 - Energy Conversion Systems

Teaching Scheme:
Lecture: 3 Hrs./ Week

Examination
Paper: 100 Marks
Paper Duration: 3 Hrs.

Unit I: Classification of Energy Sources

- Classification of Energy Sources,
- Principle fuels for energy conversion: Fossil fuels, Nuclear fuels.
- Conventional & Renewable Energy
- Energy Sources: prospecting, extraction and resource assessment and their peculiar characteristics.
- Direct use of primary energy sources, Conversion of primary into secondary energy
- sources such as Electricity, Hydrogen, Nuclear energy etc.
- Energy Conversion through fission and fusion, Nuclear power generation etc.

Unit II: Thermal and Mechanical Energy

- Conversion of Thermal Energy to Mechanical energy & Power.
- Steam turbines, Hydraulic turbines, Gas turbine
- Combined cycle analysis – Inter- cooling, reheating and regeneration-gas turbine cooling.
- Design for high temperature - Combined cycles with heat recovery boiler – Combined cycles with multi-pressure steam - STAG combined cycle power plant - Influence of component efficiencies on cycle performance.

Unit III: Thermal and Mechanical Energy Utility systems

- Boilers -Types, combustion in boilers, performance evaluation, analysis of losses, feed water treatment, blow down.
- FBC Boilers: Introduction, mechanism of fluidized bed combustion, advantages, types of FBC boilers, operational features, retrofitting FBC system to conventional boilers.
- HVAC, Refrigeration and Air Conditioning: Vapor compressor refrigeration cycle, refrigerants, coefficient of performance, capacity, factors affecting refrigeration and air conditioning system performance, Vapor absorption refrigeration systems: Working principle, type and comparison with vapor compressor system.

Unit IV: Co-generation, Tri-generation & Waste Energy Recovery

- Co-generation & Tri-generation: Definition, need, application, advantages, classification, saving Potential.
- Waste Heat Recovery: Concept of conversion efficiency, energy waste, waste heat recovery classification, advantages and applications, commercially viable waste heat recovery devices.

Unit V: Mechanical Energy Utility Systems-I

- Compressed Air System: Types of air compressors, compressors efficiency, efficient compressors operation, Compressed air system components, capacity assessment, and leakage test, factors affecting the performance.

- Fans and blowers: Types, performance evaluation, efficient system operation, flow control strategies.

Unit VI: Mechanical Energy Utility Systems-II

- Pumps and Pumping Systems: Types, performance evaluation, efficient system operation, flow control strategies, variable speed drives.
- Cooling Towers: Types and performance evaluation, efficient system operations, flow control strategies, assessment of saving opportunities.
- Diesel generating systems: Factors affecting selection, energy performance assessment of diesel conservation avenues.

Assignments/ Labwork(Any Four):

1. Study of energy sources
2. Trial on hydraulic turbine to find the operating and main characteristic curves
3. Trial on boiler to find equivalent evaporation and energy balance sheet
4. Performance evaluations of HVAC systems
5. Case study on waste heat recovery systems
6. Performance evaluation of an air compressor

References:

1. Principles of Energy Conversion : A.W.Culp (McGrawHill International
2. Industrial Furnaces (Vol I & II) and M.H. Mawhinney, (John Wiley Publications)
3. Refractories – F.H. Nortan,(John Wiley Publication.)
4. Domestic and commercial oil Burners Charles H. Burkhadt (McGraw Hill Publication)
5. Boilers – Types, Characteristics and functions – Carl D. Shields (Mcgraw Hill book)
6. Principles of Refrigeration R.J. Dossat (Wiley Estern Limited.)
7. Stoichiometry – Bhatt, Vora (Tata Mc.Graw Hill)
8. Practical Heat Recovery – Boyen J.L. (John Wiley, New York, USA1976)
9. Instrument Engineers handbook (VolI,II,III)– B.G. Liptak Chintan Book Comp / CRC Publication
10. Analysis and design of Energy Systems - Hogde B.K. (Prentice Hall, 1988)
11. Energy management and control system – Vol-I, II –M.C. Macedo (John Willy)
12. Energy Conservation guide book Patrick / Fardo (Prentice hall1993)

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502504 A - Elective-I Nuclear Materials and Reactor Fundamentals

Teaching Scheme:
Lecture: 3 Hrs. / Week

Examination
Paper: 100 Marks
Paper Duration: 3 hrs.

Unit I: Nuclear Materials I :

- Introduction to properties and selection of materials for nuclear steam supply systems and radiation effects on materials.
- Implications of radiation damage to reactor materials and materials problems in nuclear engineering.

Unit II : Nuclear Materials II :

- Overview of nuclear steam supply systems, crystal structure and defects, dislocation theory, mechanical properties
- Radiation damage, hardening and embrittlement due to radiation exposure
- Problems concerned with fission and fusion materials.

Unit III:Radiation and reactor fundamentals:

- Basics of nuclear physics and reactor physics.
- Atomic and nuclear models, nuclear reactions, nuclear fission, radioactive decay, neutron interactions,

Unit IV: Nuclear Reactors:

- Nuclear reactors
- Neutron diffusion in non-multiplying and multiplying systems, and basic nuclear reactor kinetics.

Unit V: Nuclear Fuel cycle:

- Processing of nuclear fuel with description of mining, milling, conversion, enrichment, fabrication, irradiation, shipping, reprocessing and waste disposal.

Unit VI: Nuclear Fuel cycle Economics:

- Fuel cycle economics and fuel cost calculation. In-core and out-of-core nuclear fuel management, engineering concepts and methodology.

Assignments/ Labwork(Any Four):

1. Study of nuclear materials
2. Study fission and fusion of nuclear reactions
3. Study of nuclear radiations and their impact on environment
4. Study of processing of nuclear fuels
5. Study of nuclear fuel cycle
6. Economic analysis of nuclear fuel

References:

1. M. M. El-Wakil: Nuclear Power Engineering, McGraw Hill, 1962
2. R. H. S. Winterton: Thermal Design of Nuclear Reactors, Pergamon Press, 1981
3. R. L. Murray: Introduction to Nuclear Engineering, Prentice Hall, 1961

4. Olander, Donald R., "Fundamental Aspects of Nuclear Reactor Fuel Elements," TID-26711-P1, Technical Information Center, Springfield, Virginia, March 1985
5. Smith, Charles, O., “Nuclear Reactor Materials,” Addison-Wesley, Reading, MA, 1967.

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502504 B - Elective-I Process Optimization

Teaching Scheme:
Lecture: 3 Hrs./ Week

Examination
Paper: 100 Marks
Paper Duration: 3 Hrs.

Unit I: System Simulation

- Classification.
- Successive substitution method - examples.
- Newton Raphson method – one unknown - examples.
- Newton Raphson method - multiple unknowns - examples.
- Gauss Seidel method - examples.
- Rudiments of finite difference method for partial differential equations, with an example.

Unit II: Regression and Curve Fitting

- Need for regression in simulation and optimization.
- Concept of best fit and exact fit.
- Exact fit - Lagrange interpolation, Newton's divided difference - examples.
- Least square regression - theory, examples from linear regression with one and more unknowns - examples.
- Power law forms - examples.
- Gauss Newton method for nonlinear least squares regression - examples.

Unit III: Optimization

- Introduction.
- Formulation of optimization problems – examples.
- Search methods – Concept of interval of uncertainty, reduction ratio, reduction ratios of simple search techniques like exhaustive search, dichotomous search, Fibonacci search and Golden section search – numerical examples.
- Method of steepest ascent / steepest descent, conjugate gradient method – examples.
- Geometric programming –examples.
- Dynamic programming – examples.
- Linear programming – two variable problem –graphical solution.
- New generation optimization techniques – Genetic algorithm and simulated annealing - examples.
- Introduction to Bayesian framework for optimization - examples.

Unit IV: Orthogonal Arrays:

- Different test strategies
- Degrees of freedom, selection of a standard orthogonal array
- ANNOVA / S/N ratios for static problems
  S/N ratios for dynamic problems
- TAGUCHI Technique
- Case study 1 - matrix experiment using orthogonal arrays

Unit V: Designing a optimized product / process

- Case study 2,
  - Selection of noise factors and testing conditions
  - Quality characteristics and objective function
  - Control factors and their levels
  - Matrix experiment and Data Analysis

Unit VI: Nontraditional Optimization Techniques

- Fuzzy logic and neural networks
- Genetic algorithm and Genetic Programming

Assignments/ Labwork(Any Four):

1. Assignment on curve fitting problems
2. Assignment on linear programming
3. Assignments on nonlinear programming
4. Assignment on geometric programming
5. Assignment on ANNOVA
6. Assignment on nontraditional programming

References:

1. Essentials of Thermal System Design and Optimization, Prof. C.Balaji, Aue Books, New Delhi in India and CRC Press in the rest of the world.
2. Design and optimization of thermal systems,Y .Jaluria, Mc Graw Hill, 1998.
3. Elements of thermal fluid system design, L.C. Burmeister, Prentice Hall, 1998.
4. Design of thermal systems, W.F. Stoecker, Mc Graw Hill, 1989.
5. Introduction to optimum design, J.S.Arora, Mc Graw Hill, 1989.
6. Optimization for engineering design - algorithms and examples, K.Deb, Prentice Hall, 1995.
7. Floudas, C.A., 223 Nonlinear and Mixed Integer Optimization: Fundamentals and Applications224, Oxford University Press, New York, 1995.
8. T.F.Edgar and D.M.Himmelblau, Optimization of Chemical Processes, McGraw Hill International Editions, Chemical Engineering Series (1989)
9. G.S.Beveridge and R.S.Schechter, Optimization Theory and Practice, Mc Graw Hill, New York 1970.
10. G.V.Rekllaitis, A.Ravindran, and K.M.Ragsdell, "Engineering Optimization- Methods and Applications", John Wiley, New York (1983)

502504 C Elective-I Plant Operation, Dynamics and Control

Teaching Scheme:
Lecture: 3 Hrs. / Week

Examination
Paper: 100 Marks
Paper Duration: 3 Hrs.

Unit I Introduction

- Course overview.
- Evolution of system dynamic analysis and control design technology.
- Control system terminology.

Unit II Mathematical Models

- Introduction to system modeling and examples, the perturbation equation.
- Linear systems versus nonlinear systems, linearization of nonlinear models.
- State space models, empirical or data-driven models.

Unit III Nuclear Plant operation

- Major systems in a Pressurized Water Reactor (PWR).
- Major systems in a Boiling Water Reactor (BWR).
- CANDU (Canadian-Deuterium-Uranium) pressured heavy water reactor (PHWR).
- High-Temperature Gas-Cooled Reactor (HTGR).

Unit IV Laplace Transform for Linear & Transient system Analysis

- Standard forcing functions in process simulation.
- Examples of first order system responses.
- Matrix exponential solutions for linear state space models. Eigen values and eigenvectors.
- Definition of the Laplace transforms. Laplace transforms of standard functions.
- The method of residues and the inverse Laplace transform.
- Step response of a second order system.
- Laplace transform and linear state space models.
- Transfer functions of linear time-invariant systems.
- Time delay systems.

Unit V Design of Feedback Controllers

- Response characteristics of dynamic systems.
- System transfer function.
- Various control actions.
- Design methods for proportional-integral controllers.
- Example of application to a water level control problem.
- Temperature control laboratory.

Unit VI Reactor System Modeling and Control

- Point reactor kinetics equations.
- Power reactor dynamics and feedback effects.
- Modeling reactor core dynamics and simulation.
- Primary system model of a PWR.
- SIMULINK model of a PWR plant.
- Control strategies in a PWR.
- Control rod reactivity estimation.

Assignments/ Labwork(Any Four):

1. Assignment on plant operation of PWR and BWR
2. Assignment on plant operation of CANDU and HGTR
3. Assignment on design procedure of any one reactor
4. Simulation and Mathematical Modeling of any one reactor
5. Study of time delay system
6. Case study and control strategy of Reactor Systems

References:

1. Damian Flynn, Institution of Electrical Engineers, “Thermal Power Plant Simulation and Control”, IET (2003).
2. Samuel Glasstone, Alexander Sesonske, “Nuclear Reactor Engineering: Reactor systems engineering, Volume 2, Springer, 1994
3. David Lindsley, Institution of Electrical Engineers, “Power-Plant Control and Instrumentation: The Control of Boilers and Hrsg Systems”, IET (2000)

502505 A - Elective-II Electromechanical and Reactor Systems

Teaching Scheme:
Lecture: 3 Hrs. / Week

Examination
Paper: 100 Marks
Paper Duration: 3 Hrs.

Unit-I Electromechanical Systems I:
- Introduction to electromechanical systems with emphasis on modeling, analysis, design, and control techniques.

Unit-II Electromechanical Systems II:
- Design of electric machines (standard motors, linear actuators, magnetic bearings, etc).

Unit-III Electromechanical Systems III:
- Maxwell's equations, electromechanical energy conversion, finite element analysis, design and control techniques.

Unit-IV Reactor systems I:
- Nuclear power plant systems: PWR, BWR and advanced concepts.
- Design criteria, design parameters, economics, primary and secondary loops.

Unit-V Reactor systems II:
- Safety systems, Reactor control and protection systems.

Unit-VI Reactor systems III:
- Containment, accident and transient behaviors, core design, and reactivity control mechanisms.

Assignments/ Labwork(Any Four):

1. Study of electromechanical systems.
2. Design of electric machines
3. Study of electromechanical energy conversion systems
4. Study of liquid metal cooled and gas cooled reactor
5. Safety and protection system of reactors
6. Study of awareness of accident and it's remedies

References:

1. Elmer Lewis, Fundamentals of Nuclear Reactor Physics", Elsevier, (2008)
2. Austin Hughes, Don MacLoud, "Electric Motors and Drives Fundamentals, Types and Applications", Elsevier, (2005)
3. Richard Crowder," Electric Drives and Electromechanical Systems Applications and Control", Elsevier 2006.

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502505 B - Elective-II Process Integration

Teaching Scheme:
Lecture: 3 Hrs / Week

Examination
Paper: 100 Marks
Paper Duration: 3 Hrs.

Unit I

- Introduction to process Intensification and Process Integration (PI).
  Areas of application and techniques available for PI, onion diagram.

Unit II

- **Pinch Technology-an overview:**
  Introduction, Basic concepts, How it is different from energy auditing, Roles of thermodynamic laws, problems addressed by Pinch Technology.
- **Key steps of Pinch Technology:**
  Concept of ΔTmin, Data Extraction, Targeting, Designing, Optimization-Super targeting
- **Basic Elements of Pinch Technology:**
  Grid Diagram, Composite curve, Problem Table Algorithm, Grand Composite Curve.

Unit-III

- **Targeting of Heat Exchanger Network:**
  Energy Targeting, Area Targeting, Number of units targeting, Shell Targeting and Cost targeting.

Unit-IV

- **Designing of HEN:**

  Pinch Design Methods, Heuristic rules, stream splitting, design of maximum energy recovery(MER).

  Use of multiple utilities and concept of utility pinches, Design for multiple utilities pinches, Concept of threshold problems and design strategy.

  Network evolution and evaluation-identification of loops and paths, loop breaking and path relaxation.

  Design tools to achieve targets, Driving force plot, remaining problem analysis, diverse pinch concepts, MCp ratio heuristics.

Unit-V

- Targeting and designing of HENs with different ΔTmin values, Variation of cost of utility, fixed cost, TAC, number of shells and total area with ΔTmin Capital-Energy trade-offs.
- Process modifications-Plus/Minus principles, Heat Engines and appropriate placement of heat engines relative to pinch.
- Heat pumps, Appropriate placement of heat pumps relative to pinch.

- Steam Rankin Cycle design, Gas turbine cycle design, Integration of Steam and Gas turbine with process.

Unit-VI

- Refrigeration systems, Stand alone and integrated evaporators.
- Heat integrations and proper placement of Reactors for batch Processes as well as continuous processes.
- Retrofit of distillation systems.

Assignments/ Labwork (Any Four):

1. Study of process Intensification and Process Integration (PI).
2. Case study on energy audit and pinch technology
3. Study of Data Extraction, Targeting,
4. Study of Designing, Optimization-Super targeting
5. Cost analysis of HENs
6. Retrofit of distillation systems

References:

1. Shenoy U. V., Heat Exchanger Network Synthesis: Processes Optimization by Energy and Resource Analysis, Gulf Publishing Company, Houston, 1995.
2. Douglas J. M., Conceptual Design of Chemical Processes, McGraw-Hill, New York,1988.
3. Mahmoud M. El-Halwagi, Process Integration, Academic Press, 2006
4. Great Britain. Energy Efficiency Office, Process Integration for the Design of Energy Efficient Buildings: An R and D Study on Process Integration for the Design of Energy Efficient Buildings, Energy Efficiency Office, 1989.
5. Mahmoud M. El-Halwagi, Sustainable Design Through Process Integration, Elsevier, 2011.
6. Smith R.; "Chemical Process Design", McGraw-Hill
7. Linnhoff B., Townsend D. W., Boland D, Hewitt G. F., Thomas B. E. A., Guy A. R., and Marsland R. H.; "A User Guide on Process Integration for the Efficient Uses of Energy", Inst. Of Chemical Engineers .

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502505 C Elective-II Non Conventional Energy Sources

Teaching Scheme:
Lecture: 3 Hrs./ Week

Examination
Paper: 100 Marks
Paper Duration: 3 Hrs.

Unit-I Solar energy

- The Sun – Production and transfer of solar energy – Sun-Earth angles –
- Availability and limitations of solar energy – Measuring techniques and estimation of solar radiation.
- Solar thermal collectors – General description and characteristics.

Unit-II Solar Energy collection

- Flat plate collectors – Heat transfer processes – Short term and long term collector performance.
- Solar concentrators – Design, analysis and performance evaluation.

Unit-III Energy storage

- Sensible heat storage, Liquid media storage – Solid media storage – Dual media storage –Phase change energy storage.
- Storage capacity – Other storage methods – Solar dehumidification – Design, performance and applications.
- Combined solar heating and cooling systems – Performance and cost calculations – Special topics on solar energy.

Unit-IV Energy from biomass:

- Sources of biomass – Different species
- Conversion of biomass into fuels – Energy through fermentation – Pyrolysis, gasification and combustion – Aerobic and anaerobic bio-conversion
- Properties of biomass
- Biogas plants – Types of plants – Design and operation – Properties and characteristics of biogas.

Unit-V Wind energy:

- Principles of wind energy conversion – Site selection considerations
- Wind power plant design
- Types of wind power conversion systems – Operation, maintenance and economics

Unit-VI Geothermal and other energy resources:

- Availability, system development and limitations, Ocean thermal energy conversion, Wave and tidal energy –Scope and economics, Introduction to integrated energy systems.

Assignments/ Labwork (Any Four):

1. Study of solar energy collectors
2. Case study of solar energy storage
3. Study of Energy from Biomass

4. Evaluation of Energy Content in Wind. (Prototype Wind Mill of 500W)
5. Study of Geothermal energy
6. Study of Ocean and Tidal energy

References:

1. J.A. Duffie and W.A. Beckman: Solar Energy Thermal Processes, J. Wiley, 1994
2. A.A.M. Saigh (Ed): Solar Energy Engineering, Academic Press, 1977
3. F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 1978
4. G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers, 2002
5. H.P. Garg, S.C. Mullick and A.K. Bhargava: Solar Thermal Energy Storage, 1985
6. K.M. Mittal: Non-conventional Energy Systems-Principles, Progress and Prospects, Wheeler Publications, 1997
7. G.D. Rai: Non-conventional Energy Sources, Khanna Publishers, 2003
8. S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, second edition, Tata McGraw-Hill, New Delhi, 1996
9. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, second edition, John Wiley, New York, 1991
10. D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000
11. D. D. Hall and R. P. Grover, Biomass Regenerable Energy, John Wiley, New York, 1987.

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Semester II

502508 Convective Heat Transfer

Teaching Scheme:
Lecture: 3 Hrs. / Week

Examination
Paper: 100 Marks
Paper Duration: 3 Hrs.

Unit-I

- Convection: Energy equation – thermal boundary layer.
- Forced Convection – Practical correlations –flow over surfaces – internal flow. Natural convection, combined forced and free convection

Unit-II

- Combined convection and radiation in flows.
- Fundamentals of convective heat transfer in microtubes and channels – Thermodynamic concepts, general laws and particular laws - Governing equations and size effects.

Unit-III

- Single phase forced convection in microchannels – Flow structure – entrance length – experimental observations on flow and heat transfer characteristics – Theoretical investigations – Forced convection in mixtures - Gas flow in microchannels.

Unit-IV

- Boiling and two- phase flow heat transfer in small channels – Boiling curve and critical heat flux - flow patterns – Bubble dynamics and thermodynamic aspects.

Unit-V

- Applications of microchannel heat transfer – microchannel heat sinks – micro heat pipes and micro heat spreaders – integration of microchannel heat sinks and heat spreaders to silicon structures – experimental and theoretical investigations.

Unit-VI

- Condensation: modes and mechanisms – correlations and problems.
- Heat Exchangers: Heat Exchanger types –LMTD method and the effectiveness – NTU method.

Assignments/ Labwork (Any Four):

1. Study of single phase forced convection in micro channels
2. Study of convective heat transfer in microtubes and channels
3. Performance evaluation of Heat exchangers
4. Verification of Dropwise and Filmwise condensation
5. Study of Boiling and critical heat flux of nichrome wire
6. Simulation of parallel and counter flow Heat exchangers

References:

1. J.P. Holman., 'Heat and Mass Transfer', Tata McGraw Hill, 8th Ed., 1989.

2. D.D. Kern, ‘Extended Surface Heat Transfer’, New Age International Ltd., 1985.
3. F.P. Incropera and D. P. Dewit, ‗Fundamentals of Heat and Mass Transfer’, 4th Ed. John Wiley & Sons, 1998.
4. C.P. Kothandaraman., Fundamentals of Heat and Mass Transfer’, 2nd Ed., New Age International, 1997.
5. E.R.D Eckert and R.M. Drake, ‗Analysis of Heat and Mass Transfer’, McGraw Hill, 1980.
6. Kays, W.M. and Crawford W., ‗Convective Heat and Mass Transfer’, McGraw Hill Inc., 1993.
7. Burmister L.C., ‘Convective Heat Transfer’, John Willey and Sons, 1983.
8. Satish, K., Srinivas, G., Dongqing, L., Stephane, C., and Michael R. K., Heat Transfer and Fluid Flow in Minichannels and Microchannels, First Edition, Elsevier, 2005.
9. Garimella, S. V. and C. B. Sobhan, C. B., Transport in Microchannels – A Critical Review, in Annual Review of Heat Transfer, Begell House, NY, 2004.
10. Chen, G., Nanoscale Energy Transport and Conversion, Oxford University Press, 2005.
11. Bejan, Convective Heat Transfer, John Wiley, Inc.

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502509 Energy Systems Modeling and Analysis

Teaching Scheme:
Lecture: 3 Hrs. / Week

Examination
Paper: 100 Marks
Paper Duration: 3 Hrs.

Unit-I

- Modelling overview-levels of analysis, steps in model development, examples of models.
- Quantitative Techniques: Interpolation-polynomial, Lagrangian. Curve-fitting, regression analysis, solution of transcendental equations.

Unit-II

- Systems Simulation-information flow diagram, solution of set of nonlinear algebraic equations, successive substitution, Newton Raphson. Examples of energy systems simulation

Unit-III

- Optimisation :Objectives / constraints, problem formulation. Unconstrained problems- Necessary & Sufficiency conditions. Constrained Optimisation-Lagrange multipliers, constrained variations, Kuhn-Tucker conditions.

Unit-IV

- Linear Programming - Simplex tableau, pivoting, sensitivity analysis. Dynamic Programming. Search Techniques- Univariate / Multivariate.

Unit-V

- Case studies of optimisation in Energy systems problems. Dealing with uncertainty- probabilistic techniques. Trade-offs between capital & energy using Pinch Analysis.

Unit-VI

- Energy- Economy Models: Scenario Generation, Input Output Model. Numerical solution of Differential equations- Overview, Convergence, Accuracy. Transient analysis- application example.

Assignments/ Labwork (Any Four):

1. Case studies of optimisation in Energy systems problems
2. Case Study of sensitivity analysis
3. Study of Energy- Economy Models
4. Assignment on Quantitative Techniques
5. Assignment on linear programming
6. Assignments on nonlinear programming

References:

1. W. F. Stoecker Design of Thermal Systems, Mc Graw Hill, 1981
2. S.S. Rao Optimisation theory and applications, Wiley Eastern, 1990
3. S.S. Sastry Introductory methods of numerical analysis,Prentice Hall, 1988
4. P. Meier Energy Systems Analysis for Developing Countries, Springer Verlag, 1984
5. R de Neufville Applied Systems Analysis Mcgraw Hill International Edition 1990
6. R.de Neufville, Applied Systems Analysis, Mcgraw Hill, International Edition, 1990
7. Beveridge and Schechter,Optimisation Theory and Practice, Mcgraw Hill, 1970

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502510 Energy Management

Teaching Scheme:
Lecture: 3 Hrs./ Week

Examination
Paper: 100 Marks
Paper Duration: 3 Hrs.

Unit-I

- Importance of energy management. need of energy management and scope of energy management

Unit-II

- **Energy auditing**: methodology, analysis of past trends (plant data), closing the energy balance, laws of thermodynamics, measurements, portable and on line instruments.

Unit-III

- **Steam Systems**: Boiler –efficiency testing, excess air control, Steam distribution & use- steam traps, condensate recovery, flash steam utilisation. Thermal Insulation.

Unit-IV

- **Electrical Systems**: Demand control, power factor correction, load scheduling/shifting, Motor drives- motor efficiency testing, energy efficient motors, motor speed control. Lighting- lighting levels, efficient options, fixtures, day lighting, timers, Energy efficient windows. Energy conservation in Pumps , Fans (flow control), Compressed Air Systems, Refrigeration & air conditioning systems.

Unit-V

Waste heat recovery: recuperators, regenerators, heat pipes, heat pumps. Cogeneration - concept, options (steam/gas turbines/diesel engine based), selection criteria, control strategy. Heat exchanger networking- concept of pinch, target setting, problem table approach, composite curves. Demand side management.

Unit-VI

- **Nuclear waste Management**: Scientific and engineering aspects of nuclear waste management. Management of spent fuel, high-level waste, uranium mill tailings, low-level waste and decommissioning wastes. Fundamental processes and governing equations for the evaluation of waste management systems with emphasis on the safety assessment of waste disposal facilities. Regulations and policy issues.

Assignments/ Labwork (Any Four):

1. Wind power and annual energy estimation from wind data.
2. Energy audit of small scale industry.
3. Pay back analysis, financial work sheet of a renewable energy project.
4. Study of waste heat recovery system
5. Determination of COP of cooling towers.
6. Nuclear Techniques in Environmental Studies.

References:

1. Industrial Energy Conservation Manuals, MIT Press, Mass, 1982.
2. I.G.C.Dryden, Butterworths, The Efficient Use of Energy, London, 1982
3. W.C.Turner, Wiley, Energy Management Handbook, New York, 1982.
4. Technology Menu for Efficient energy use- Motor drive systems, Prepared by National Productivity Council and Center for & Environmental Studies- Princeton Univ 1993.

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502511 A Elective-III Radiation Safety and Shielding

Teaching Scheme:
Lecture: 3 Hrs./ Week

Examination
Paper: 100 Marks
Paper Duration: 3 Hrs.

Unit-I

- Radiation safety and environmental aspects of nuclear power generation.
- Radiation interaction, photon attenuation

Unit-II

- Radiation Shielding, internal and external dose evaluation
- Reactor effluents and release of radioactivity into the environment, transportation and disposal of radioactive waste

Unit-III

- Environmental impact of nuclear power plants.
- Radiation hazards

Unit-IV

- Surface contamination and control
- Radiation emergency preparedness

Unit-V

- Protection against radiation exposure
- Nuclear power plant safety requirements

Unit-VI

- Conceptual design of safety systems

Assignments/ Labwork (Any Four):

1. Studies of environmental aspects and safety of radiation
2. Study of Radiation Shielding
3. Study of Radiation hazards
4. Study of Nuclear power plant safety requirements
5. Design of safety systems
6. Precautions and awareness of radiation accidents

References:

1. E.E. Lewis, Nuclear Power Reactor Safety, Wiley Inter-science, 1977
2. J. Kenneth Shultis, Richard E. Faw, “Radiation shielding”, Prentice Hall PTR, 1996
3. Jacob Shapiro, Radiation Protection: A Guide for Scientists, Regulators, and Physicians, La Editorial, UPR, 2002.
4. Harold Etherington, “Nuclear engineering handbook”, McGraw-Hill
5. M. F. Kaplan, Concrete radiation shielding: Nuclear Physics, Concrete Properties, Design and Construction, Longman Scientific & Technical, 1989
6. Arthur B. Chilton, J. Kenneth Shultis, Richard E. Faw, Principles of radiation shielding, Prentice-Hall, 1984

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502511 B Elective-III Energy and Climate

Teaching Scheme:
Lecture: 3 Hrs/ Week

Examination
Paper: 100 Marks
Paper Duration: 3 Hrs.

Unit-I

- Energy and us: Energy terms; Current energy scenario (World, US, India) Fossil energy Vs renewable sources; Electricity; Future projections; Externalities of energy use.

Unit-II

- Carbon Cycle: Natural systems – autotrophs, heterotrophs, energy flows, pre-industrial humanity; Photosynthesis- efficiency of natural ecosystems, forests and various crops; Respiration, combustion and other oxidation processes; Biomethanation

Unit-III

- Climate Science Research: Climate history; Greenhouse gas effect; Anthropogenic climate change; Role of different gases; Global problem; Integrated assessment models; Impacts and adaptation; Uncertainties; Precautionary principle

Unit-IV

- Carbon Sequestration: Biological pathways; Physico-chemical methods; CO_2 capture from large point sources; Pre-, post- and oxy-combustion technology; Transport, storage and monitoring; Feasibility, economics and public perceptions; Case studies

Unit-V

- Climate Policy: Kyoto protocol; UNFCCC; IPCC; Geopolitics of GHG control;

Unit-V

- Carbon market - CDM and other emission trading mechanisms; Non-CO_2 GHGs; Relevance for India

Assignments/ Labwork (Any Four):

1. Studies of Current energy scenario of India and world
2. Study of carbon cycle and carbon credit
3. Study of Anthropogenic climate change
4. Case Study on Carbon market
5. Study of Climate Policy
6. Study of Environmental impact

References:

1. Energies: V Smil, MIT Press, Cambridge, 1999.
2. Global Warming: J Houghton, Cambridge University Press, New York, 1997
3. IPCC Special Report on Carbon Dioxide Capture and Storage: B Metz et al (Eds), Cambridge University Press, NY, 2005.
4. CDM Country Guide for INDIA: Institute for Global Environmental Strategies (Ed), Ministry of the Environment, Japan, 2005.
5. Global Environmental Issues:F Harris (Ed),John Wiley,Chichester, 2004.

6. “Carbon Capture and Sequestration: Integrating Technology, Monitoring, and Regulation” edited by E J Wilson and D Gerard, Blackwell Publishing, Ames, Iowa, USA, 2007
7. Energy and the environment: J A Fay and D S Golomb, Oxford University Press, New York, 2002.
8. Introduction to Engineering and the Environment: E S Rubin, McGraw Hill, New York, 2001

502511 C Elective-III Energy Regulatory Frameworks

Teaching Scheme:
Lecture: 3 Hrs./ Week

Examination
Paper: 100 Marks
Paper Duration: 3 Hrs.

Unit-I

- Energy policies of India - Supply focus approach and its limitations - Energy paradigms – DEFENDUS approach - End use orientation - Energy policies and development - Case studies on the effect of Central and State policies on the consumption and wastage of energy - Critical analysis - Need for renewable energy policies in India.

Unit-II

- Legislation for regulation and its effective implementation for nuclear power plants. Role of Central and State Electricity Regulatory Commissions

Unit-III

- Role of Atomic Energy Regulatory Board (AERB) and Department of Atomic Energy (DAE)

Unit-IV

- Legislation, rules and regulations for safe electricity generation:-
  The Factories Act 1948, Applicable AERB Safety Codes, Guides and Technical Specifications, The Atomic Energy Act 1962, The Indian Electricity Act 1910, The Environmental Protection Act 1986, The Air (Prevention and Control of Pollution) Act 1981, The Water (Prevention and Control of Pollution) Act 1974, The Boiler Act.

Unit-V

- Compliance with legal and regulatory requirements

Unit-VI

- Surveillance requirements and systems
- Comparison with the regulatory framework of conventional industry

Assignments/ Labwork (Any Four):

1. Study of Energy policies of India
2. Study of Role of Atomic Energy Regulatory Board (AERB) and Department of Atomic Energy (DAE)
3. Study of Compliance with legal and regulatory requirements
4. Case Study on Surveillance requirements and systems
5. Case studies on the effect of Central and State policies on the consumption and wastage of energy

References:

1. J. Goldemberg, T.B. Johansson, A.K.N. Reddy and R.H. Williams: Energy for a Sustainable World, Wiley Eastern, 1990.
2. IEEE Bronze Book: Energy Auditing, IEEE Publications, 1996
3. P. Chandra: Financial Management Theory and Practice, Tata McGraw Hill, 1992
4. Annual Energy Planning Reports of CMIE, Govt. of India
5. A.K.N. Reddy and A.S. Bhalla: The Technological Transformation of Rural India, UN Publications, 1997
6. A.K.N. Reddy, R.H. Williams and J.B. Johanson: Energy After Rio-Prospects and Challenges, UN Publications, 1997
7. P. Meier and M. Munasinghe: Energy Policy Analysis & Modeling, Cambridge University Press, 1993
8. R.S. Pindyck and D.L. Rubinfeld: Economic Models and Energy Forecasts, 4e, McGraw Hill, 1998

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502512 A Elective-IV Nuclear Measurement and Detection

Teaching Scheme:
Lecture: 3 Hrs./ Week

Examination
Paper: 100 Marks
Paper Duration: 3 Hrs.

Unit-I Radiometric quantities and interaction coefficients:

Radiation field; fluence (rate); energy fluence (rate); cross section; mass attenuation coefficient; mass stopping power

Unit-II Dosimetric quantities

Exposure (rate); kerma (rate); energy imparted; absorbed dose (rate); linear energy transfer (LET), lineal energy; organ dose

Unit-III Radiation protection quantities

Equivalent dose (rate); radiation weighting factor (wR); Effective dose, tissue weighting factor (wT); operational quantities: ambient dose equivalent; directional dose equivalent; personal dose equivalent; intake; committed dose Lecture notes

Unit-IV Dosimetric calculations

Relationship between fluence, kerma and absorbed dose; air kerma rate constant; calculation of kerma and absorbed dose Bragg-Gray cavity principle; measurement of absorbed dose with ionization in gas filled cavity; electronic equilibrium; composition of homogeneous cavity; large cavity; small cavity; recombination effects; correction factors for determination of absorbed dose to water in photon and electron beams Point sources, plane sources, and volume sources; absorption and scattering in air and in the body; attenuation of primary radiation and buildup of secondary radiation; concepts of extended and aligned fields; influence of geometry Calculation of dose from neutron sources Micro dosimetry; tissue equivalent detectors

Unit-V Detectors

Gas filled detectors Ionization chambers with current measurements; condenser chambers; pressure ionization chamber; extrapolation chambers; proportional chambers; GM tubes Scintillation detectors Solid and liquid scintillators; quenching Semiconductor detectors Photographic emulsions Thermoluminescent detectors Nuclear track detectors Neutron detectors Detectors using (n,□) or (n,p) reactions or activation or others Imaging detectors Other detectors: electrets; self-powered detectors; thermally stimulated exoelectron emission (TSEE); radiophotoluminescent detectors (RPLD)

Unit-VI Measurement techniques

Efficiency (geometric and intrinsic), background, geometry, statistics; pulse counting scalers and rate meters; discriminators; resolution; pulse height analysis – coincidence and anticoincidence; pulse shape analysis; computer analysis of spectra.

Assignments/ Labwork (Any Four):

1. Studies of Nuclear measurement techniques
2. Study of Dosimetric quantities
3. Study of Radiation protection quantities
4. Case Study on Nuclear Measurement and Detection
5. Study of Radiation protection quantities
6. Study of Detectors

References:

1. Glenn F. Knoll, Radiation Detection and Measurement, John Wiley & Sons, 2010
2. Michael Fiederle, Arnold Burger, Larry Franks, Nuclear Radiation Detection Materials – 2011, Materials Research Society, 2012.
3. Glenn F. Knoll, Radiation Detection and Measurement, John Wiley & Sons, 2010
4. S.S. Kapoor, V. Ramamurthy, Nuclear Radiation Detectors, New Age International, 1993

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502512 B Elective-IV Energy Resources and Economics

Teaching Scheme:
Lecture: 3 Hrs./ Week

Examination
Paper: 100 Marks
Paper Duration: 3 Hrs.

Unit-I

- Overview of World Energy Scenario – Dis-aggregation by end-use, by supply
- Fossil Fuel Reserves – Estimates
- Duration Overview of India's Energy Scenario - Dis-aggregation by end-use, by supply

Unit-II

- Reserves Country Energy Balance Construction – Examples
- Trends in energy use patterns
- Energy and development linkage.

Unit-III

- Energy Economics - Simple Payback Period, Time Value of Money, IRR, NPV, Cost of Saved Energy, Cost of Energy generated,
- Examples from energy generation and conservation
- Elements of nuclear power plant cost

Unit-IV

- Cash flows covering the entire life cycle
- Cost estimation and revision methods
- Cost of capital

Unit-V

- Unit energy cost
- Mandatory liabilities like decommissioning and international safeguard obligations
- Financial planning, analysis and control

Unit-VI

- Interest during construction
- Comparison of cost of nuclear power plant with thermal & other power plants
- Energy Chain, Primary energy analysis Life Cycle Assessment, Net Energy Analysis.

Assignments/ Labwork (Any Four):

1. Studies of Fossil Fuel Reserves – Estimates
2. Study of Trends in energy use patterns
3. Study of Energy Economics
4. Study on Cost estimation and revision methods
5. Study of Financial planning, analysis and control
6. Study of Life Cycle Assessment and Net Energy Analysis.

References:

1. Energy and the Challenge of Sustainability, World energy assessment, UNDP New York, 2000.

2. AKN Reddy, RH Williams, TB Johansson, Energy after Rio, Prospects and challenges, UNDP, United Nations Publications, New York, 1997.
3. Nebojsa Nakicenovic, Arnulf Grubler and Alan McDonald Global energy perspectives, Cambridge University Press, 1998
4. Ferdinand E. Banks, Energy Economics: A Modern Introduction, Springer, 2000

502512 C Elective-IV Processing Storage and Disposal of Nuclear Waste

Teaching Scheme:
Lecture: 3 Hrs./ Week

Examination
Paper: 100 Marks
Paper Duration: 3 Hrs.

Unit-I

- Radioactivity, radio nuclides and types of radioactive waste
- Sources of nuclear waste

Unit-II

- Nuclear decay law
- Short-lived and Long-lived waste radio nuclides.

Unit-III

- Characterization of radioactive waste
- Approaches to nuclear waste management

Unit-IV

- Pre-treatment of radioactive wastes
- Techniques of nuclear waste processing

Unit-V

- Performance and safety assessment methods
- Radioactive waste recycling, waste minimization and immobilization
- Contaminants and hazards

Unit-VI

- Background radiation
- Nuclear waste regulations
- Treatment/immobilization of solid and liquid radioactive wastes

Assignments/ Labwork (Any Four):

1. Studies of Radioactivity and radio nuclides
2. Study of Short-lived and Long-lived waste radio nuclides
3. Study of Approaches to nuclear waste management
4. Study Pre-treatment of radioactive wastes
5. Study of Nuclear waste regulations
6. Study of Treatment/immobilization of solid and liquid radioactive wastes

References:

1. Warren S. Melfort, Nuclear Waste Disposal: Current Issues and Proposals, Nova Publishers, 2003.
2. Robert Noyes, Nuclear Waste Cleanup Technologies and Opportunities, Elsevier, 1995.
3. M. I. Ojovan, W. E. Lee; An Introduction to Nuclear Waste Immobilisation, Elsevier, 2005.