Department of Mechanical Engineering  
Curriculum for M. Tech. Programme in Energy Engineering

**Semester 1**

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**Semester 4**

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**Total Credits: 60**

**Stipulations:**

1. A minimum of 60 credits have to be earned for the award of M. Tech. degree in this programme.
2. Students have to credit a minimum of eight core courses and four electives during the programme; however they have option to credit two electives in the Third Semester, drawing one each from First and Second Semesters.
3. Students may undergo Industrial Training during May-June.
### List of Electives

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<td>Optimal design of heat exchangers</td>
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<td>Energy policies for sustainable development</td>
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<td>Environmental engineering and pollution control</td>
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<td>ME6433</td>
<td>Emerging trends in refrigeration systems</td>
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<td>Hydrogen production, storage and transportation</td>
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<td>ME6439</td>
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*Note: Students may choose any course offered in the Institute with the approval from the Programme Coordinator.*
DEPARTMENT OF MECHANICAL ENGINEERING

BRIEF SYLLABI

M. Tech. Programme in Energy Engineering

Pre-requisite for courses: Nil
Total Hours for all courses except for Project: 42
Lecture hours for theory courses: 3
Hours for Practical/Seminar: 3
Credit for theory courses: 3
Credit for Practical/Seminar: 1

MA6001 MATHEMATICAL METHODS

ME6402 ADVANCED ENERGY CONVERSION SYSTEMS

ME6403 RENEWABLE ENERGY TECHNOLOGY

EE6410 ELECTRICAL ENERGY SYSTEMS AND MANAGEMENT

ME6491 COMPUTATIONAL LABORATORY
Hands on training on commercial application softwares like IDEAS, MATLAB, FLUENT, etc. Development of user friendly softwares. Programming assignments on numerical methods.

ME6411 HEAT TRANSFER IN ENERGY SYSTEMS

ME6412 DESIGN AND ANALYSIS OF ENERGY SYSTEMS

ME6413 ENERGY CONSERVATION IN THERMAL SYSTEMS
ME6414 ENERGY AND ENVIRONMENT

ME6493 ENERGY MANAGEMENT LABORATORY
Experiments with energy related equipments like heat exchanger, refrigeration system, heat pump, air-conditioning coils, heat pipe, solar water heaters, solar stills, biomass gasifier, fluidized bed system, waste heat recovery system, photovoltaic system, wind energy system, etc.

ME6421 DIRECT ENERGY CONVERSION
Basic science of energy conversion. Thermodynamic considerations. Photovoltaic conversion. Types, construction and operating characteristics of solar cells. Typical layouts for solar cell and current developments. Thermolectric and thermionic converters. MHD. Electrochemical conversion. Fuel cell types and design. Wind energy conversion systems. OTEC. Wave and tidal energy conversion.

ME6422 OPTIMAL DESIGN OF HEAT EXCHANGERS

ME6423 ENERGY POLICIES FOR SUSTAINABLE DEVELOPMENT

ME6424 FLUIDIZED BED SYSTEMS

ME6425 HEAT PUMP TECHNOLOGY

ME6426 MICROCHANNEL FLOW AND MIXING ANALYSIS

ME6427 ENERGY EFFICIENT BUILDINGS

ME6428 INTEGRATED ENERGY SYSTEMS
ME6429 THEORY OF COMBUSTION
Thermodynamics of combustion processes, transport phenomena and reaction mechanisms, partial equilibrium assumptions and pressure effect, oxidative characteristics of fuels, explosion limits of fuels, premixed laminar flames, stability limits of flames, detonation phenomena, Hugoniot theory, detonation waves, burning of condensed phases and droplet cloud, chain and thermal spontaneous ignition, environmental combustion considerations.

ME6430 ADVANCED AIR BREATHING PROPULSION
Air-breathing and rocket engines, chemical reactions for propulsion applications, performance parameters, ramjet engine, combustion instability and its suppression, testing of ramjets, ram-rockets, integrated ramjet-rocket systems, hypersonic air-breathing propulsion, SCRAM jet engines, liquid air-cycle engines, space plane applications, experimental and testing facilities.

ME6431 CRYOGENIC ROCKET PROPULSION SYSTEMS
Liquid propellant rocket engine, generation of thrust, performance parameters, liquid propellants, rocket-engine design parameters, mission requirements, thrust chamber elements, injectors, ignition devices, combustion instability, determination of pressurant requirements, turbo pump-fed systems, propellant pumps, turbine power sources, cryogenic propellant tank design, liquid propellant engine control systems, space applications.

ME6432 ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL
Fundamentals of environment- house gases and effect –Global warming–Ozone Depletion Acid rain, Natural Cycles- air pollution- water pollution- pollution from industries and instrumentation

ME6433 EMERGING REFRIGERATION TECHNOLOGIES
Refrigeration systems- Introduction to nonconventional refrigeration technologies- Thermoelectric refrigeration, magnetic refrigeration, Thermo-acoustic refrigeration, steam jet refrigeration, vortex tube refrigeration- Modern refrigerants

ME6434 HYDROGEN - PRODUCTION, STORAGE AND TRANSPORTATION
Need for Hydrogen Energy- Prospects for a Cleaner Planet- Production of Molecular Hydrogen- Thermo-Chemical Hydrogen Production Process and Direct Chemical Path- Gas Separation- Transportation, Distribution and Storage

ME6435 HYDROGEN ENERGY CONVERSION TECHNOLOGY

ME6436 ENERGY MODELING, ECONOMICS AND PROJECT MANAGEMENT

ME6437 HYDROPOWER SYSTEMS

ME6438 INFORMATION TECHNOLOGY IN ENERGY MANAGEMENT
Need for software engineering in energy management- Survey of software life cycle models software engineering, Introduction to computer application, IT system, database management system, computer based monitoring and online control system- Programming languages- Energy Management concepts and CBIS. Intelligence based system - energy data bases - networking - time sharing concepts- Transform theory of software performance - network model of structured programs. Data acquisition systems - expert based systems for energy management – Parallel Processing Concepts - Typical applications in energy management area.

ME6439 RECENT ADVANCES IN REFRIGERANTS
Refrigeration cycles and role of the refrigerants in the refrigerating system- commercially used refrigerants- Types of refrigerants- Properties of refrigerants- Alternative refrigerants-ecofriendly refrigerants - Preparation of mixtures of refrigerants - analysis of properties of mixtures - performance of CFC12, HCFC22 alternatives - modifications required for retrofitting, safety precautions and compatibility of refrigerants with the materials
MA6001 MATHEMATICAL METHODS

Pre-requisite: Nil
Total Hours: 42

Module I   Linear Algebra (11 Hours)

Module II   Series Solutions of ODE and Sturm-Liouville (10 Hours)
Power series solutions about ordinary point, Legendre equation and Legendre polynomials, Solutions about singular points; The method of Frobenius, Bessel equation and Bessel Functions. Sturm-Liouville problem and Generalized Fourier series.

Module III Partial Differential Equations (11 Hours)
First order PDEs, Linear equations, Lagrange method, Cauchy method, Charpits method, Jacobi method. Second order PDEs, Classifications, Formulation and method of solutions of Wave equation, Heat equation and Laplace equation.

Module IV Tensor Calculus (10 Hours)
Line, area and volume integrals, Spaces of N-dimensions, coordinate transformations, covariant, contravariant and mixed tensors, fundamental operation with tensors, Quotient Law the line element and metric tensor, conjugate tensor, Christoffel’s symbols, covariant derivative.

References:
ME6401 ADVANCED ENERGY CONVERSION SYSTEMS

Pre-requisite: Nil
Total Hours: 42

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**Module I (12 hours)**

Classification of energy sources - Utilization, economics and growth rates - Fossil fuels, nuclear fuels and solar energy - Combustion calculations - Conventional thermal power plant design and operation - Superheat, reheat and regeneration - Other auxiliaries of thermal plant - High-pressure boilers - Steam generator control.

**Module II (10 hours)**

Gas turbine and 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.

**Module III (10 hours)**

Nuclear energy conversion - Chemical and nuclear equations - Nuclear reactions -Fission and fusion - Energy from fission and fuel burn-up - Radioactivity – Neutron energies - Fission reactor types - Nuclear power plants - Fast breeder reactor and power plants - Production of nuclear fuels.

**Module IV (10 hours)**

Fuel rod design - Steam cycles for nuclear power plants - reactor heat removal – Coolant channel orificing - Core thermal design - Thermal shields - Fins in nuclear plants – Core thermal hydraulics - Safety analysis - LOCA - Time scales of transient flow and heat transfer processes.

**References**

ME6402 RENEWABLE ENERGY TECHNOLOGY

Pre-requisite: Nil
Total Hours: 42

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Module I (12 hours)


Module II (10 hours)


Module III (10 hours)


Module IV (10 hours)

Wind energy – Principles of wind energy conversion – Site selection considerations – Wind power plant design – Types of wind power conversion systems – Operation, maintenance and economics – Geothermal energy – Availability, system development and limitations – Ocean thermal energy conversion – Wave and tidal energy – Scope and economics – Introduction to integrated energy systems.

References

EE6001 ELECTRICAL ENERGY SYSTEMS AND MANAGEMENT

Pre-requisite: Nil
Total Hours: 42

Module I (10 hours)

Module II (11 hours)

Module III (11 hours)
Types and operating characteristics of electric motors - Energy efficient control and starting - Load matching - Selection of motors - Efficiency and load analysis – Energy efficiency - High efficiency motors - Industrial drives - Control schemes - Variable speed drives and Energy conservation schemes - Pumps and fans - Efficient control strategies - Over-sizing - Case studies.

Module IV (10 hours)

References
6. UNESCAP-Guide Book on Promotion of Sustainable Energy Consumption (www.unescap.org/enrd/energy)
ME6491 COMPUTATIONAL LABORATORY

1. Commercial Software Training

- Design, modeling and analysis (I-DEAS)
- Development of user friendly packages (V-Studio)
- Mathematical tools used in engineering (MATLAB)
- Computational fluid dynamics and heat transfer (FLUENT)

2. Programming Assignments on the Following Topics:

- Roots of algebraic and transcendental equations
- Solution of simultaneous algebraic equations
- Curve fitting and optimization
- Numerical integration and differentiation
- Numerical solution of ODEs: Initial value problems
- Numerical solution of ODEs: Boundary value problems
- Numerical solution of PDEs

References


ME6492 SEMINAR

Each student shall prepare a seminar paper on any topic of interest based on the core/elective courses being undergone in the first semester in the field of specialization – Energy Engineering. He/she shall get the paper approved by the Programme Coordinator/Faculty Advisor/Faculty Members in the concerned area of specialization and present it in the class in the presence of Faculty in-charge of seminar class. Every student shall participate in the seminar. Grade will be awarded on the basis of the student’s paper, presentation and his/her participation in the seminar.
ME6411 FLUID FLOW AND HEAT TRANSFER IN ENERGY SYSTEMS

Pre-requisite: Nil
Total Hours: 42

Module I (11 hours)

Review of fundamental concepts – continuum, control volume, Eulerian and Lagrangian methods of description of fluid flow; Reynolds transport equation – integral and differential forms of continuity, momentum, and energy equations, Navier-Stokes equations and boundary conditions; Nondimensionalization of equations and order of magnitude analysis, dimensionless parameters and their significance; classification of flows based on the characteristic Reynolds number; equations for low and high Reynolds number flows.

Module I (11 hours)

Differential formulation of general heat transfer problems - Types of boundary conditions – Homogeneous equations and boundary conditions. Conductive heat transfer in energy systems - Practical examples including nuclear reactors, solar thermal collectors, heat exchangers, energy storage systems, etc.

Module III (10 hours)

Convective heat transfer in energy systems - Differential formulation of heat and fluid flow - Discussion on relevant boundary conditions - Convection models for solar flat plate collectors, solar ponds, boiler tubes, etc.

Module IV (10 hours)


References

ME6412 DESIGN AND ANALYSIS OF ENERGY SYSTEMS

Pre-requisite: Nil
Total Hours: 42

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Module I (10 hours)

Engineering design fundamentals - Designing a workable system - Economic evaluation - Fitting data and solving equations - Design optimization - Knowledge based system design.

Module II (10 hours)

Heat exchanger design calculations - Evaporators and condensers temperature concentration pressure characteristics of binary solutions - Rectifiers - Cooling towers - Pressure drop and pumping power.

Module III (10 hours)

Pump characteristics - Manufacturer's specifications - Relations among performance characteristics - Pump system operation - Cavitation prevention - Other system considerations, Fans and nozzles.

Module IV (12 hours)


References

ME6413 ENERGY CONSERVATION IN THERMAL SYSTEMS

Pre-requisite: Nil
Total Hours: 42

Module I (11 hours)

Module II (11 hours)
Thermodynamics and economics - Systematic approach to steam pricing - Pricing other utilities - Investment optimization - Limits of current technology - Process improvements - Characterizing energy use - Optimum performance of existing facilities - Steam trap principles - Effective management of energy use - Overall site interactions - Total site cogeneration potential - Linear programming approach.

Module III (10 hours)

Module IV (10 hours)

References
ME6414 ENERGY AND ENVIRONMENT

Pre-requisite: Nil
Total Hours: 42

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Module I (10 hours)


Module II (11 hours)

Air Pollution: Classification of air pollutants, sources of emission and air quality standards - Physical and chemical characteristics - Meteorological aspects of air pollutant dispersion - Temperature lapse rate and stability - Factors influencing dispersal of air pollutant - Air pollution dispersion models - Air pollution sampling and measurement - types - Ambient air sampling - Gaseous air pollutants - Particulate air pollutants - Analysis of air pollutants

Module III (10 hours)

Air Pollution Control methods and Water Pollution: Types of controls – Particulate emission control - Gaseous emission control - Sources and classification of water pollutants - Waste water sampling and analysis - Basic process of waste water treatment - Primary treatment - Secondary treatment - Advanced treatment Methods of feed water treatment.

Module IV (10 hours)

Environmental impact assessment: Air quality and water quality standards – Pollution prevention and control acts - Principles and methodology of Environmental impact assessment, Air and water quality impacts by project type.

References

1. C. S. Rao: Environmental Pollution Control Engineering, Wiley Eastern, 1992
Study and Experiments on Energy Systems from the Following List:
1. Heat Exchanger
2. Refrigeration Systems and heat pumps
3. Air-conditioning Coils
4. Heat pipes
5. Energy Efficient Chulah
6. Wind Energy System
7. Solar PV System
8. Solar Water and Air Heaters
9. Solar Still
10. Biomass Gasifiers
11. Fluidized Bed System
12. Waste Heat Recovery Systems

Students are free to select any one assignment from the following term paper/mini project/industrial training.

Term Paper: Prepare a review paper on any topic in energy engineering with the individual analysis and comments.

Mini project: Students can select any project work and work under the guidance of any teaching staff in the department. End of the semester, each student has to submit a thesis report. Project work is evaluated by the department as per M. Tech. regulations.

Industrial Training: Who are opting for industrial training, as to undergo a minimum of four weeks training in well established industries during in the summer vacation after the first two semesters. He has to submit a report on his training to the department and the same is evaluated as per M. Tech. regulations.
ME7495 PROJECT WORK

The student will be encouraged to fix the area of the project work and conduct the literature review during the second semester itself. The project work starts in the third semester. The topic shall be research and development oriented. The project can be carried out at the institute or in an industry/research organization. They are supposed to complete a good quantum of the work in the third semester. There shall be evaluation of the work carried out in the third semester.

ME7496 PROJECT WORK

The project work started in the third semester will be extended to the end of the fourth semester. The project can be carried out at the institute or in an industry/research organization. Students desirous of carrying out project in industry or other organization have to fulfill the requirements as specified in the “Ordinances and Regulations for M. Tech.”. There shall be evaluations of the project work by a committee constituted by the department and by an external examiner.

Regulations for M. Tech. under the section - Project Work in Industry or Other Organization

At the end of the third semester, the students’ thesis work shall be assessed by a committee and graded as specified in the “Ordinances and Regulations for M. Tech.”. If the work has been graded as unsatisfactory, the committee may recommend a suitable period by which the project will have to be extended beyond the fourth semester. At the end of the fourth semester, the student shall present his/her thesis work before an evaluation committee, which will evaluate the work and decide whether the student may be allowed to submit the thesis or whether he/she needs to carry out additional work. The final viva-voce examination will be conducted as per the “Ordinances and Regulations for M. Tech.”
ME6421 DIRECT ENERGY CONVERSION SYSTEMS

Pre-requisite: Nil
Total Hours: 42

Module I (10 hours)
Basic science of energy conversion - Orderly and disorderly energy - Reversible and irreversible engines - Analysis of basically reversible engines - Duality of matter - Thermoelectric Vs Photoelectric phenomena - Basic thermoelectric engine - Thermoelectric materials - Applications.

Module II (10 hours)
Physics of solar photovoltaic cells - Production of solar cells - Design concept of PV cell systems - Solar cells connected in series and parallel - Voltage regulation and energy storage - Centralized and decentralized PV Systems - Maintenance of PV systems - Current developments.

Module III (12 hours)
Thermionic emission - Richardson’s equation - Analysis of high vacuum thermionic converter - Gaseous converters - Introduction to MHD generators - Seeding and ionization in MHD generators - Analysis of MHD engines and MHD equations - Conversion efficiency and electrical losses in MHD power generation systems.

Module IV (10 hours)
Definition, general description, types, design and construction of fuel cells - Thermodynamics of ideal fuel cells - Practical considerations - Present status - Future energy technologies - Hydrogen energy - Nuclear fusion.

References
4. S.W. Angrist: Direct Energy Conversion, 4e, Allwyn & Bycon, 1982
7. N.B. Breiter: Electro chemical Processes in Fuel Cells, Spring-Verlag, 1969

*PS: This subject is to be handled by 50:50 sharing basis between MED & EED
ME6422 OPTIMAL DESIGN OF HEAT EXCHANGERS

Pre-requisite: Nil
Total Hours: 42

Module I (11 hours)

Heat exchanger classification and design fundamentals - LMTD-NTU rating and sizing problems - Theta methods - NTU rating and sizing problems - Dimensionless groups - Steady-state temperature profiles - Optimization criteria - Core pressure loss.

Module II (11 hours)

Direct sizing of heat exchangers - Plate fin exchangers - Exchanger lay up – Surface geometries - Distribution headers - Multi-stream design - Helical-tube exchangers - Design frame work - Basic and simplified geometries - Fine tuning and design for curved tubes - Bayonet tube exchangers - Isothermal and non-isothermal shell side conditions - Explicit, complete and non-explicit solutions.

Module III (10 hours)

Transients in heat exchangers - Fundamental equations - Solution methods – Analytical considerations - Method of characteristics - Direct solution by finite differences - Engineering applications.

Module IV (10 hours)


References

ME6423 ENERGY POLICIES FOR SUSTAINABLE DEVELOPMENT

Pre-requisite: Nil
Total Hours: 42

Module I (11 hours)

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.

Module II (11 hours)


Module III (10 hours)

Energy conservation schemes - Statutory requirements of energy audit - Economic aspects of energy audit - Capital investments in energy saving equipment - Tax rebates - Advantages of 100% depreciation – India’s plan for a domestic energy cap & trade scheme.

Module IV (10 hours)

Social cost benefit analysis - Computation of IRR and ERR - Advance models in energy planning - Dynamic programming models in integrated energy planning - Energy planning case studies - Development of energy management systems - Decision support systems for energy planning and energy policy simulation.

References

4. Annual Energy Planning Reports of CMIE, Govt. of India
ME6424 FLUIDIZED BED SYSTEMS

Pre-requisite: Nil
Total Hours: 42

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Module I (10 hours)

Introduction to fluidized bed technology - Regimes of fluidized behavior - Heat transfer in fluidized bed - Residence time distribution and size distribution in fluidized bed – Heat transfer to immersed surfaces in fluidized and packed beds.

Module II (12 hours)

Theory of fluidized bed combustion (FBC) - System design for combustion and gasification - Fluidized bed combustion systems for power plants - Air distribution design - Combustion efficiency - Start up and shut down - Combustion of coal in fluidized beds – De sulfurization of coal in fluidized bed - Use of wood and agricultural waste for fluidized bed combustion.

Module III (10 hours)

Mathematical modeling of fluidization process - Multiphase models - Fluidized bed gasification systems - Production of gaseous fuels form coal in fast fluidized beds -Chemically active fluidized bed gasifier - Conversion of gas in bubbling beds -Entrainment and elutriation.

Module IV (9 hours)

Fluidized bed heat exchangers - Fluidized bed furnaces and boilers - Fluidized bed steam generator for liquid metal fast breeder reactor - Pressurized fluidized bed combustion boilers - Pressurized adiabatic and pressurized air tube fluidized bed combustion.

References

ME6425 HEAT PUMP TECHNOLOGY

Pre-requisite: Nil
Total Hours: 42

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Module I (9 hours)

Module II (11 hours)

Module III (12 hours)

Module IV (10 hours)
Advances in heat pumps - Improvements and innovations - Advanced cycles for vapor absorption heat pumps - Peltier-effect heat pumps - Magnetic heat pumps - Heat transformers - Metal hydride heat pumps - Energy basis comparison of convention and advanced heating and cooling systems.

References
ME6426 MICRCHANNEL FLOW AND MIXING ANALYSIS

Pre-requisite: Nil
Total Hours: 42

Module I (10 hrs)

Module II (10 hrs)

Module III (11 hrs)
Diffusion, mixing and separation in Microsystems – Advection–diffusion equation – Analysis of dispersion phenomena – Introduction to turbulence and chaos – Chaotic mixing and chaotic advection – Cascade models for turbulence and mixing analysis – Examples for mixing in Microsystems.

Module IV (11 hrs)

References
ME6427 ENERGY EFFICIENT BUILDINGS

Pre-requisite: Nil
Total Hours: 42

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Module I (11 hrs)

Module II (10 hrs)

Module III (10 hrs)

Module IV (11 hrs)

References

*PS: This subject is to be handled by 50:50 sharing basis between MED & AED*
ME6428 INTEGRATED ENERGY SYSTEMS

Pre-requisite: Nil
Total Hours: 42

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**Module I (10 hrs)**

Energy consumption pattern – Projection of energy demands – Possible substitution of conventional sources – Modern technological options – Introduction to hybrid and integrated energy systems – Total energy concept and waste heat utilization.

**Module II (11 hrs)**


**Module III (11 hrs)**

Optimal design of hybrid energy systems – Special optimization techniques applicable – Energy economics and cost optimization of integrated energy systems – Sample problems and case studies.

**Module IV (10 hrs)**

Integration of various power generation systems – Feasibility studies – Site selection – Related social, economic and technical problems – Special role of wind and biogas systems – Future prospects and case studies.

**References**


*PS: This subject is to be handled by 50:50 sharing basis between MED & EED*
Module I (10 hrs)


Module II (11 hrs)

Explosive and general oxidative characteristics of fuels: Chain branching reactions, criteria for explosions. Explosion limits and oxidation characteristics of Hydrogen, carbon monoxide and hydrocarbons. Flame phenomena in premixed combustible gases: Laminar flame speed, stability limits of laminar flames. Turbulent flames

Module III (10 hrs)


Module IV (11 hrs)


References

ME 6430 ADVANCED AIR BREATHING PROPULSION

Pre-requisite: Nil
Total Hours: 42

Module I (10 hrs)
Introduction: Propulsion, units, operational envelopes and standard atmosphere, air-breathing engines, aircraft performance, rocket engines.

Review of Fundamentals: Equations of state, conservation of mass, conservation of energy, steady flow momentum equation, steady flow entropy equation, compressible flow properties, chemical reactions for propulsion applications.

Module II (11 hrs)
Principles of air breathing propulsion, performance parameters, ramjet engine: Cycle and performance analysis, supersonic inlets, combustors for liquid fuel ramjet engines, combustion instability and its suppression, solid fuel ramjet engines, testing of ramjets.

Module III (10 hrs)
Ramrockets: Performance analysis, ducted and shrouded types, air-augmented rockets, integrated ramjet-rocket systems, nozzle less solid propellant rockets and integrated ramjet-rocket boosters, dump combustors and associated combustion problems, computational fluid dynamics techniques in the design and development of combustors.

Module IV (11 hrs)
Hypersonic air-breathing propulsion, SCRAM jet engines: Methods of analysis, hypersonic intakes, supersonic combustors, engine cooling and materials problem, CFD applications, liquid air-cycle engines, space plane applications, experimental and testing facilities, the shock tunnel.

References
ME6431 CRYOGENIC ROCKET PROPULSION SYSTEMS

Pre-requisite: Nil
Total Hours: 42

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Module I (10 hours)

**Introduction to liquid propellant rocket engines:** Basis elements of liquid propellant rocket engines, generation of thrust, gas flow processes in the combustion chamber and nozzle, performance parameters of liquid propellant rocket engines, liquid propellants- Earth storable and cryogenic, engine requirements and preliminary analysis- major rocket engine design parameters, mission requirements, Engine design philosophy, Preliminary design, sample calculations

Module II (10 hours)

**Thrust chambers and other combustion devices:** Basic thrust chamber elements, thrust chamber performance parameters, specific impulse, characteristic velocity, thrust coefficient, performance calculations, thrust chamber configuration layout, heat transfer and fluid flow, injectors, ignition devices, combustion instability

Module III (11 hours)

**Typical engine cycles and new trends, gas pressurized propellant feed system:** Determination of pressurant requirements, turbo pump propellant feed system, elements of turbo pump fed systems, propellant pumps, turbines, turbine power sources, turbo pump drive arrangements, turbo pump design parameters, turbo pump system performance and design, design of centrifugal pumps, axial flow pumps, turbine design, turbo pump-rotodynamics and mechanical elements, propellant tanks, cryogenic propellant tank design, insulation requirements for cryogenic propellant tanks, basic insulation types, selection of tank insulation designs, insulation for common bulk heads

Module IV (11 hours)

**Rocket engine control and condition monitoring systems:** Basic liquid propellant engine control systems, engine thrust level control, propellant mixture ratio and propellant utilization control, thrust vector control, CCM concepts and preliminary design development, control methods, control law development, design of fluid flow control devices, engine systems integration, space engines and considerations, space applications, reaction control engine requirements, altitude control weight, reliability and material considerations.

References

1. HILL, PHILIP G, PETERSON, CARL R, Mechanics and thermodynamics of propulsion
2. ZUCROW, M.J., Air craft and missile propulsion
3. CARTON, D.S., Rocket propulsion technology
4. JAUMOTTE, A.L., Combustion and propulsion
5. BONNEY, E. Arthur, Aerodynamics propulsion structures and design practical
6. FLACK, RONALD D., Fundamentals of jet propulsion with applications
7. YAHYA, S.M., Fundamentals of compressible flow with aircraft and rocket propulsion
8. T LANCASTER O.E., Jet propulsion engines
9. KUENTZ, CRAIG, Understanding rockets and their propulsion
ME6432 ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL

Pre-requisite: Nil
Total Hours: 42

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Module I (10 hours)


Module II (11 hours)

AIR POLLUTION: Classification of air pollutants, sources of emission and air quality standards - Meteorological aspects of air pollutant dispersion - Temperature lapse rate and stability - Factors influencing dispersal of air pollutant - Air pollution dispersion models - Air pollution sampling and measurement - Control Methods and Equipments - Issues in Air Pollution control

Module III (11 hours)

WATER POLLUTION: Water resources -Sources and classification of water pollutants - Waste water analysis - Basic process of water treatment - Primary treatment -Secondary treatment - Advanced treatment. Disposal of Sludge - Monitoring compliance with Standards

Module IV (10 hours)

POLLUTION FROM INDUSTRIES AND INSTRUMENTATION: Noise Pollution and its impact - Oil Pollution - Pesticides - Instrumentation for EIA test - Instrumentation related with parameter of pollutants – Environment Impact assessment for various projects – Case studies

References

1. C. S. Rao: Environmental Pollution Control Engineering, Wiley Eastern, 1992
ME6433 EMERGING REFRIGERATION TECHNOLOGIES

Pre-requisite: Nil

Module I (10 hours)

Introduction to refrigeration systems, methods of refrigeration, units of refrigeration, COP, Review of vapour compression refrigeration system, vapour absorption system, Introduction to nonconventional refrigeration technologies- Thermoelectric refrigeration, magnetic refrigeration, pulse tube refrigeration, acoustic refrigeration, steam jet refrigeration, vortex tube refrigeration.

Module II (10 hours)

Thermoelectric refrigeration-principle, thermoelectric properties, Seabeck effect, Peltier effect, System description, performance, analysis, Applications

Module III (10 hours)

Introduction to Magnetic refrigeration, magneto-caloric effect, magnetic materials, magnetic refrigeration near room temperature cooling, advantages over traditional refrigeration system, clean refrigeration in future-pulse tube refrigerator-principle-analysis

Module IV (12 hours)

Principles and application of steam jet refrigeration system, Performance, vortex tube refrigeration system, system description, Applications

Modern refrigerants - Need for alternative refrigerants – eco friendly refrigerants - properties of mixtures of refrigerants-modifications required for retrofitting, safety precautions and compatibility of refrigerants with the materials.

References

ME6434 HYDROGEN - PRODUCTION, STORAGE AND TRANSPORTATION

Pre-requisite: Nil
Total Hours: 42

Module I (11 Hrs)


Module II (11 Hrs)

Module III (10 Hrs)


Module IV (10 Hrs)
Transportation, Distribution and Storage, Strategic Considerations, Distribution and Bulk Storage of Gaseous, Dewars for transport applications Gas Cylinders, Pipelines, Large-scale Storage, Metal Hydrides, Chemical and Related Storage, Simple Hydrogen-bearing Chemicals, Complex Chemical Hydrides, Nano-structured Materials, Hydrogen Storage in Road Vehicles, Industrial scale pressurized hydrogen storage.

References
ME6435 HYDROGEN ENERGY CONVERSION TECHNOLOGY

Pre-requisite: Nil
Total Hours: 42

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Module I (10 Hrs)


Module II (14 Hrs)


Module III (8 Hrs)

**Fuel Cell engine Vehicles (FCVs):** Fuel cells as alternative to internal combustion Buses, Delivery Vehicle, Cars and other Automobiles, non transport applications, Submarines, **Hybrid Electric Vehicles (HEVs),** Conventional versus Hybrid Vehicles.

Module IV (10 Hrs)

**Traction mechanisms:** Used for Fuel cell operated, Comparison with Pure battery operated, Combo drives: Battery & fuel cell, Battery & Hydrogen cum Gasoline engine, Fuel cell & Hydrogen cum Gasoline engine.

**Metering, instrumentation and safety issues:** EMS, safety issues, Instrumentation in H2 usage. leak detectors used in production, transport and conversion, Hydrogen sniffer leak detection solution. Problems in hydrogen usage: hydrogen embrittlement, hydrogenation of oils

References

17. PEM FUEL CELLS, Frano Barbir, www.amazon.com
19. The Hydrogen Energy Transition Moving Toward the Post Petroleum Age in Transportation
20. Edited by: Daniel Sperling and James S. Cannon
ME6436 ENERGY MODELING, ECONOMICS AND PROJECT MANAGEMENT

Pre-requisite: Nil
Total Hours: 42

Module I (12 Hrs)


Module II (10 Hrs)

Basic concept of econometrics and statistical analysis: The 2-variable regression model; The multiple regression model; Tests of regression coefficients and regression equation; Econometric techniques used for energy analysis and forecasting with case studies form India; Operation of computer package Input – Output Analysis, Basic concept of Input-output analysis; concept of energy multiplier and implication of energy multiplier for analysis of regional and national energy policy; Energy and environmental Input - Output analyses using I-O model

Module III (10 Hrs)

Energy Modeling: Interdependence of energy-economy-environment; Modeling concept, and application, Methodology of energy demand analysis; Methodology for energy forecasting; Sectoral energy demand forecasting; Interfuel substitution models; SIMA model, and I-O model for energy policy analysis; Simulation and forecasting of future energy demand consistent with macroeconomic parameters in India; Energy Economics and Policies: National and Sectoral energy planning; Integrated resource planning; Energy pricing

Module IV (10 Hrs)

Project Evaluation & Management: Financial analysis: Project cash flows, time value of money, life cycle approach & analysis, conception, definition, planning, feasibility and analysis; Project appraisal criteria; Risk analysis; Project planning matrix; Aims oriented project planning; Social cost benefit analysis. Network analysis for project management; Time estimation; Critical path determination; PERT, CPM and CERT; Fuzzy logic analysis; Stochastic based formulations; Project evaluation techniques; Funds planning; Project material management, evaluation & analysis; Implementation and monitoring; Performance indices; Case studies.

2 Autonomous Fossil Fuel and renewable energy (RE)-based Power Systems

References

6. Forecasting Methods and Applications, S.Makridakis , Wiley 1983
ME6437 HYDROPOWER SYSTEMS

Pre-requisite: Nil
Total Hours: 42

Module I (10 Hrs)

Module II (10 Hrs)

Module III (10 Hrs)

Module IV (10 Hrs)

References
2. Hydraulic Turbines, Krevichenko, MIR Publishers
5. Power Plant Evaluation and Design (1988), Tyler G.Hicks
websites:
ME6438 INFORMATION TECHNOLOGY IN ENERGY MANAGEMENT

Pre-requisite: Nil
Total Hours: 42

Module I (10 Hrs)

The need for software engineering in energy management. Survey of software life cycle models software engineering, Introduction to computer application, IT system, database management system, computer based monitoring and online control system.

Module II (10 Hrs)


Module III (10 Hrs)

Types of CBIS - Relationship among CBIS system concepts and CBIS - general systems theory - Energy Management concepts and CBIS. Intelligence based system - energy data bases - networking - time sharing concepts.

Module IV (10 Hrs)

Transform theory of software performance - network model of structured programs. Data acquisition systems - expert based systems for energy management – Parallel Processing Concepts - Typical applications in energy management area.

References

5. Software Engineering, Pressman, Addison Wesley
ME6439 RECENT ADVANCES IN REFRIGERANTS

Pre-requisite: Nil
Total Hours: 42

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Module I (9hrs)

**Refrigeration cycles and role of the refrigerants in the refrigerating system:** Refrigeration cycles – representation in p-h, T-s coordinates - theoretical and practical cycles - losses in refrigeration system, subcooling, superheating and components of the system – role of refrigerant in the system – commercially used refrigerants.

Module II (8hrs)

**Types of refrigerants:** Primary and secondary refrigerants – examples, natural refrigerants, organic and inorganic refrigerants, chloro fluoro carbons, hydro fluoro carbons, hydrofluoroethers.

Module III (12hrs)

**Properties of refrigerants:** Thermodynamic properties – boiling point, freezing point, critical pressure, critical temperature, condenser and evaporator pressures, coefficient of performance, power per ton.

Thermo physical properties - thermal conductivity, viscosity, surface tension, latent heat of vapourization, specific heat in both the phase.

Chemical properties – Toxicity, flammability, reaction with materials of components, reaction with oils.

Environmental properties – Ozone layer depletion, Global warming potential.

Selection of refrigerants for specific applications.

Module IV (10hrs)

**Alternative refrigerants:** Need for alternative refrigerants – ecofriendly refrigerants - Preparation of mixtures of refrigerants - analysis of properties of mixtures - performance of CFC12, HCFC22 alternatives - modifications required for retrofitting, safety precautions and compatibility of refrigerants with the materials.

References


Journals

1. International Journal of Refrigeration
2. Applied Thermal Engineering
3. ASHRAE Transactions
4. International Journal of Energy research
5. International Journal of Applied Thermal Engineering

Handbooks


Websites

www.brazewag.com/refrigeration
www.iiftr.org
www.suva.dupont.ca/

Software