

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech in ENERGY SYSTEMS
Effective from Academic Year 2017 - 18 Admitted Batch
COURSE STRUCTURE AND SYLLABUS
I Semester

Category	Course Title	Int. marks	Ext. marks	L	T	P	C
PC-1	Applied Thermodynamics	25	75	4	0	0	4
PC-2	Thermal & Nuclear Power Plants	25	75	4	0	0	4
PC-3	Advanced Heat Transfer	25	75	4	0	0	4
PE-1	1. Wind & Tidal Energy 2. Instrumentation & Control Systems 3. Design & Optimization of Energy Systems	25	75	3	0	0	3
PE-2	1. Photovoltaic & Solar Thermal Systems 2. Applied Fluid Mechanics 3. Energy Storage Systems	25	75	3	0	0	3
OE-1	*Open Elective - I	25	75	3	0	0	3
Laboratory I	Energy Systems Laboratory	25	75	0	0	3	2
Seminar I	Seminar - I	100	0	0	0	3	2
Total		275	525	21	0	6	25

II Semester

Category	Course Title	Int. marks	Ext. marks	L	T	P	C
PC-4	Renewable Energy technologies	25	75	4	0	0	4
PC-5	Energy Conversion and Management	25	75	4	0	0	4
PC-6	Cogeneration And Combined Cycle Power Plants	25	75	4	0	0	4
PE-3	1. Power Plant Protection and Switch Gear 2. Refrigeration and Air Conditioning 3. Pollution Control and Environment	25	75	3	0	0	3
PE4	1. Power Distribution Systems 2. Hydrogen & Fuel Cells 3. Environment and Safety Engineering	25	75	3	0	0	3
OE-2	*Open Elective - II	25	75	3	0	0	3
Laboratory II	Modelling & Simulation Lab	25	75	0	0	3	2
Seminar II	Seminar - II	100	0	0	0	3	2
Total		275	525	21	0	6	25

III Semester

Course Title	Int. marks	Ext. marks	L	T	P	C
Technical Paper Writing	100	0	0	3	0	2
Comprehensive Viva-Voce	0	100	0	0	0	4
Project work Review II	100	0	0	0	22	8
Total	200	100	0	3	22	14

IV Semester

Course Title	Int. marks	Ext. marks	L	T	P	C
Project work Review III	100	0	0	0	24	8
Project Evaluation (Viva-Voce)	0	100	0	0	0	16
Total	100	100	0	0	24	24

*Open Elective subjects must be chosen from the list of open electives offered by **OTHER** departments.

For Project review I, please refer 7.10 in R17 Academic Regulations.

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech. – I Year – II Sem (Energy Systems)

RENEWABLE ENERGY TECHNOLOGIES (Professional Core - IV)

UNIT- I

Wind Energy – Power in wind - Availability – Types of wind turbines - Aerodynamics of Wind turbine – Momentum theory – Dynamic matching, Construction features of wind turbines - Rotor design considerations – Power extraction by a turbine – Integration of wind energy converters to electrical networks -Applications of wind energy

UNIT- II

Biomass energy - Bio fuel – Conversion of biomass – Bio fuel classification- Biomass production for Energy farming- Direct combustion for heat- Pyrolysis- Thermo chemical process- Anaerobic digestion- Digester sizing- waste and residues- vegetable oils and biodiesels- Applications of Biogas- Social and environmental aspects

UNIT- III

Wave and Tidal Energy - Concept of energy and power from waves – Wave characteristics – period and wave velocities - Different wave energy conversion devices (Tapchan, oscillating water column type); Principles of tidal power generation - components of power plant – Single and two basin systems – Estimation of energy – Maximum and minimum power ranges

UNIT- IV

Ocean and Geothermal Energy - OTEC Principle - Lambert's law of absorption - Open cycle and closed cycle - Heat exchanger calculations (elementary treatment) – Major problems and operational experience - Classification of geothermal resource - Fundamentals of geophysics - Availability and estimation of thermal power - Extraction techniques.

UNIT- V

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

REFERENCES:

1. Renewable Energy Resources / John Twidell and Tony Weir / E & F. N. Spon
2. Energy Resources Utilization and Technologies – Anjaneyulu Y, Francis T, BS Publications.
3. Renewable Energy Resources Basic Principles and Applications / G. N. Tiwari and M. K. Ghosal / Narosa
4. Solar Energy - Principles of thermal collection and storage/ S. P. Sukhatme / TMH
5. Solar Energy Thermal Processes,/Duffie & Beckman
6. Solar Heating and Cooling / Kreith & Kreider
7. Wind Energy Handbook / Tony Burton, David Sharpe, Nick Jenkins and Ervin Bossanyi / Wiley
8. Wind Electrical Systems / S. N. Bhadra, D. Kastha and S. Banerjee / Oxford
9. Biogas Technology - A Practical Hand Book / K. Khendelwal & S.S. Mahdi / McGraw-Hill
10. Power Plant Technology / El Wakil/ McGraw Hill
11. Fuel cell/Livin Oniciu/Abacus press 1976
12. Alternative Energy Sources and Systems / Donald L. Steeby / Cengage
13. Fuel Cells-Principles & Applications-Viswanatham- University Press

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Energy Systems)

ENERGY CONVERSION AND MANAGEMENT (Professional Core - 5)

UNIT- I

Introduction: Principles of energy management. Managerial organization, Functional areas for i) manufacturing industry, ii) Process industry, iii) Commerce, iv) Government, Role of Energy manager in each of these organizations. Initiating, Organizing and managing energy management programs

UNIT - II

Energy Audit: Definition and concepts. Types of energy audits, Basic energy concepts, Resources for plant energy studies. Data gathering, Analytical techniques. Energy Conservation: Technologies for energy conservation, Design for conservation of energy materials, Energy flow networks. Critical assessment of energy usage. Formulation of objectives and constraints, Synthesis of alternative options and technical analysis of options. Process integration.

UNIT- III

Economic Analysis: Scope, Characterization of an investment project. Types of depreciation, Time value of money. Budget considerations, Risk analysis.

UNIT- IV

Methods of Evaluation of Projects: Payback, Annualized costs, Investor's rate of return, Present worth, Internal rate of return, Pros and cons of the common method of analysis, Replacement analysis.

UNIT - V

Alternative Energy Sources: Solar Energy: Types of devices for solar energy collections, Thermal storage system, Control systems. Wind Energy, Availability, Wind Devices, Wind Characteristics, performance of turbines and systems.

REFERENCES:

1. Energy Management Hand Book / W. C. Turner (Ed)
2. Energy Management Principles / CB Smith/ Pergamon Press
3. Energy Management / W. R. Murthy and G. Mc. Kay / BS Publication
4. Management / H. Koontz and Cyrill Donnel / McGraw Hill
5. Financial Management / S. C. Kuchhal / Chaitanya Publishing House

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Energy Systems.)

COGENERATION AND COMBINED CYCLE POWER PLANTS (Professional Core – 6)

UNIT - I:

Introduction-Principle of Thermodynamics- cycles-topping-bottoming-combined cycle-organic rankine cycles-performance indices of cogeneration systems-waste heat recovery-sources and types-concept of tri generation

UNIT- II:

Configuration and thermodynamic performance-steam turbine cogeneration systems- gas turbine cogeneration systems-advanced cogeneration systems: fuel cell, Stirling engines etc.,

UNIT- III:

Cogeneration plants electrical interconnection issues-utility and cogeneration plant interconnection issues-applications of cogeneration in utility sector-industrial sector-building sector-rural sector-impacts of cogeneration plants-fuel, electricity and environment

UNIT- IV:

Combined cycle power generation: Hybrid cycle – topping cycle – bottoming cycle – thermodynamic analysis- efficiency – waste heat recovery boiler – pinch point temperature importance in HRSG – Combination of steam cycle and gas turbine cycle – Integration of different power cycles – analysis – fuels used for hybrid cycles – supplementary firing of combined cycles.

UNIT- V:

Latest energy conversion techniques: Integrated Gasification combined cycle (IGCC), Advanced energy storage systems, Clean coal technologies, fluidized bed combustion, Coal based combined cycles, Natural gas based combined cycles, Integrated power generation, Fuel cells, hybrid cycles power generation with direct energy conversion principles, conversion of standalone cycle power generation into combined cycle power generation units.

REFERENCES:

1. Cogeneration-Charles H. Butler-Mc Graw Hill
2. Cogeneration-Heat and Power, Thermodynamics and Economics-Horlock JH-Oxford.
3. Power Plant Engineering, P K Nag, Tata McGraw Hill Pvt. Ltd

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech. – I Year – II Sem (Energy Systems)

POWER PLANT PROTECTION AND SWITCH GEAR (Professional Elective - 3)

UNIT - I

Protection System: Importance of protective relaying in power systems; Fundamental requirements of a good protection scheme; Zones of protection, Primary and Back-up Relaying.

Protective Relays: Terms used in protective relaying; Classifications of Relays – Constructional, Functional; Electromagnetic Relays – attracted armature, induction disc, induction cup types relays

UNIT- II

Over current and Earth fault relays, Directional, Differential, Distance Relays etc.; Principles & Characteristics of relays; Operation, setting, testing and applications, maintenance requirements of relays; Translay relay; Negative Sequence relays; Universal Relay Torque Equation; Electronic relays; Static relays; Digital relays; Microprocessor and PC based relaying; Current & Future trends.

UNIT- III

Switchgear Circuit Interruption : Fuses - Types of fuses, Terms (Fusing factor, Breaking capacity etc.), Fuse selection, HRC fuses and their applications; Arcing phenomena, Essential properties of arc, Initiation and Maintenance of an arc, Arc voltage, Arc interruption theories, Recovery and Restriking voltages, Rate of Rise of Restriking Voltage (RRRV), Resistance Switching, Inductive current chopping, Capacitive current breaking.

Circuit Breakers : AC and DC circuit breaking, Types of Circuit Breakers - ACB, OCB, ABCB, SF6CB, VCB; Static Circuit Breakers; Comparative merits and demerits of different types of CBs, Rating of Circuit Breakers, Testing and Selection of Circuit Breakers, Auto reclosing.

UNIT- IV**Power Plant Protection:**

Protection Schemes: Schemes for protection of transmission line; Merz-Price circulating current scheme, Percentage differential relay, Restricted earth fault protection, Negative Sequence protection, Translay scheme, Carrier relaying scheme, Pilot relaying scheme, Static and other relays used in transmission line protection.

Generator Protection: Neutral earthing, stator and rotor earth faults, sustained external faults, instability, protective systems. **Transformer Protection:** Various transformer protections, protective systems for Generator Transformers (GTs), Unit Auxiliary Transformers (UATs) and Station Transformers (STs).

UNIT-V

Motor Protection: Faults and Protection systems. **Busbar Protection:** Continuity of supply, Discrimination, Circulating current systems, special features relating to different voltage systems.

Feeder Protection: Continuity of supply discrimination, outline of protection systems – Pilot wire, carrier current, distance protection, PLCC – Telemetry Communication.

REFERENCE:

1. The Electricity Council: Power System Protection/ Vol.1, 2 & 3/Peter Peregrinus Ltd./1990.
2. Protective Relays: Their Theory and Practice/ Vol. 1 & 2/ Van, A. R., & Warrington, C / Chapman and Hall, 1969.
3. Transmission Network Protection: Theory and Practice/ Paithankar, Y. G./ Marcel Dekker, Inc./1998.
4. Power System Protection and Switchgear/ B. Ravindranath and M. Chander/Wiley Eastern Ltd.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
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REFRIGERATION AND AIR CONDITIONING (Professional Elective - 3)

UNIT – I

Vapour Compression Refrigeration: Performance of Complete vapor compression system.

Components of Vapor Compression System: The condensing unit – Evaporators – Expansion valve – Refrigerants – Properties – ODP & GWP - Load balancing of vapor compression Unit.

Compound Compression: Flash inter-cooling – flash chamber – Multi-evaporator & Multistage systems.

UNIT – II

Production of Low Temperature: Liquefaction system; Cascade System – Applications.– Dry ice system.

Vapor absorption system – Simple and modified aqua – ammonia system – Representation on Enthalpy – Concentration diagram.

Lithium – Bromide system Three fluid system – HCOP.

UNIT – III

Air Refrigeration: Applications – Air Craft Refrigeration -Simple, Bootstrap, Regenerative and Reduced ambient systems – Problems based on different systems.

Steam Jet refrigeration system: Representation on T-s and h-s diagrams – limitations and applications

Unconventional Refrigeration system – Thermo-electric – Vortex tube & Pulse tube – working principles.

UNIT – IV

Air –Conditioning: Psychrometric properties and processes – Construction of Psychrometric chart. Requirements of Comfort Air –conditioning – Thermodynamics of human body – Effective temperature and Comfort chart – Parameters influencing the Effective Temperature. Summer, Winter, and year round air – conditioning systems.

Cooling load Estimation: Occupants, equipments, infiltration, duct heat gain fan load, Fresh air load.

UNIT – V

Air –Conditioning Systems: All Fresh air, Re-circulated air with and without bypass, with reheat systems – Calculation of Bypass Factor, ADP, RSHF, ESHF and GSHF for different systems.

Components: Humidification and dehumidification equipment – Systems of Air cleaning – Grills and diffusers – Fans and blowers – Measurement and control of Temperature and Humidity.

REFERENCES:

1. Refrigeration & Air Conditioning /C. P. Arora/TMH
2. Refrigeration & Air Conditioning /Arora & Domkundwar/ Dhanpat Rai
3. Refrigeration and Air Conditioning /Manohar Prasad
4. Refrigeration and Air Conditioning /Stoecker /McGraw Hill
5. Basic Refrigeration & Air Conditioning – P.N. Ananthanarayanan – McGraw Hill
6. Principles of Refrigeration/Dossat /Pearson
7. Refrigeration and Air Conditioning – Dr. S.S. Thipse - Jaico
8. Refrigeration and Air Conditioning /Jordan & Preister /Prentice Hall

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Energy Systems)

POLLUTION CONTROL AND ENVIRONMENT (Professional Elective - 3)

UNIT- I

Overview of Environmental Concepts: Global Warming - Ozone Layer & UV Radiations - Deforestation - Energy & Matter Cycles - Case Studies of Significant Environmental Problems and Disasters and the lessons learnt.

UNIT- II

Air Pollution: Natural and anthropogenic sources of pollution - Primary and Secondary pollutants - Transport and diffusion of pollutants - Gas laws governing the behavior of pollutants in the atmosphere - air sampling methods - Methods of monitoring and control of air pollutants SO₂ NO₂, CO, SPM - Effect of pollutants on human beings – Plants – Animals - Materials and on climate - Acid Rain - Ambient Air Quality Standards - Air pollution control methods and equipment.

UNIT- III

Land Pollution: Sources and classification of land pollutants - Industrial waste effluents and heavy metals - Their interactions with soil components - Degradation of different insecticides - fungicides and weedicides in soil - Solid waste management - Process and equipment for energy recovery from municipal solid waste and industrial waste - MSW Act 2000.

UNIT- IV

Water Pollution: Types - Sources and consequences of water pollution – Physical - chemical and Bacteriological sampling and analysis of water quality – Standards - Sewage and waste water treatment and recycling ASP/STP - Water quality standard – Treatment - Utilization and disposal of sludge - Government norms.

UNIT- V

Marine pollution: Sources and nature of pollutants - Oil pollution - Metallic pollutants - Status of coastal and estuarine pollution in India - Chemicals and drugs from oceans - Sea level rise – Cause - effect.

REFERENCES:

1. Environmental Pollution Control Engineering. C. S. Rao, Wiley Eastern Ltd. Delhi 1991.
2. Management of Energy Environment Systems W. K. Foell John Wiley and Sons.
3. Energy Management and Control Systems M. C. Macedo, Jr. John Wiley and Sons.
4. Environmental Impact Analysis Handbook J. G. Rau, D.C. Wood, Mc Graw Hill.
5. Energy & Environment – J. M. Fowler, McGraw Hill.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
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POWER DISTRIBUTION SYSTEMS (Professional Elective - 4)

UNIT- I**Distribution System Planning:**

Load forecasting, Power Quality parameters, Choice of systems for different consumers, Planning Criteria, Standards, System layout.

UNIT- II**Distribution Lines / Cables:**

Towers/Poles, Stay wires; Conductor - Types, Characteristics & selection; Underground Cables - Selection, laying, cable box and jointing; Earth wire; Insulators & hardware fittings; Distributors, Feeders, Services Mains (LV, MV, HV); Clearances; Pole-mounted sub-stations and its location; Earthing HT & LT poles/supports; Selection & fixing of control devices.

UNIT- III**Distribution Sub-Stations:**

Types, General Arrangement, Layout, Bus-bar arrangements; Sub-station equipment – Construction details, selection and specification of equipment (distribution transformer, Circuit Breakers, etc.); Auxiliary Systems; Earthing of sub-station equipment; Basic operational aspects of equipments/systems.

UNIT- IV**Distribution Losses and Efficient Energy Management:**

Classification, Causes and Calculation of power losses; Methods of reducing power losses and Anti-theft measures; Causes and cures for breakdowns, tripping and fluctuations in distribution system; System voltage drops and improvements; Distribution transformer failures – causes & remedies; Demand Side Management (DSM), HVDS, Energy efficiency monitoring and corrective measures.

UNIT- V**Meters & Metering:**

Meters/Indicators – Types & Function; Metering system; Location of meters; Testing & Setting of meters/indicators; Latest development in metering technologies.

Cost Economics / Commercial Aspects:

Cost Engineering, Costing & Control, Estimation, Estimate for providing service (LT/HT) connections; Tariff structure & types, Rational & Competitive tariff, Energy Accounting, Energy Billing and Revenue realization.

REFERENCES:

1. Power Distribution Engineering: Fundamentals and Applications/ Burke James, J./ Marcel Dekker Inc./1996.
2. Power Distribution Planning Reference Book/ H. Lee Willis/ Marcel Dekker, Inc.
3. Electric Power Distribution Engineering/ TuranGonen/McGraw Hill.
4. Modern Trends and Practices in Power Sub-Transmission and Distribution Systems/Volumes I & II, / N. K. Jangalwa/ Central Board of Irrigation and Power/ 1996.

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HYDROGEN AND FUEL CELLS (Professional Elective - 4)

UNIT- I

Hydrogen and Production Techniques: Hydrogen – physical and chemical properties, salient characteristics. Production of hydrogen – steam reforming – water electrolysis – gasification and woody biomass conversion – biological hydrogen production – photo dissociation – direct thermal or catalytic splitting of water.

UNIT- II

Hydrogen Storage and Applications: Hydrogen storage options – compressed gas – liquid hydrogen – Hydride – chemical Storage – comparisons. Hydrogen transmission systems. Applications of Hydrogen.

UNIT- III

Fuel Cells: History – principle - working - thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery Vs fuel cell

UNIT- IV

Fuel Cell – Types: Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits

Unit- V

Application of Fuel Cell and Economics: Fuel cell usage for domestic power systems, large scale power generation, Automobile, Space. Economic and environmental analysis on usage of Hydrogen and Fuel cell. Future trends in fuel cells.

REFERENCES:

1. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma (2005)
2. Bent Sorensen (Sørensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier, UK (2005)
3. Kordesch, K and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany (1996).
4. Hart, A.B and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, NewYork Ltd., London (1989)
5. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA (2002).
6. Viswanathan, B and M AuliceScibioh, Fuel Cells – Principles and Applications, Universities Press (2006)

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M. Tech – I Year – II Sem. (Energy Systems)

ENVIRONMENT AND SAFETY ENGINEERING (Professional Elective - 4)

UNIT- I

Pollution: Air Pollution Standards; Effects of Air Pollutants on Materials, Vegetation and Health Origin and Fate of Pollutants (Carbon monoxide, Hazardous Air Pollutants, Lead, Nitrogen Dioxide, Photochemical Oxidants, Sulphur Oxides, Particulates) Acid Rain, Ozone depletion & Greenhouse effect.

Waste Water Treatment: Waste water Microbiology, Characteristics of Waste Water, Municipal and Industrial waste water treatment, Unit operation of Pretreatment, Primary Treatment, Unit processes of Secondary treatment, disinfections, Land treatment, Sludge treatment and disposal.

UNIT- II

Solid Waste Management: Waste characteristics, Disposal by Sanitary landfill, thermal conversion; combustion or incineration system, Pyrolysis, Gasification, Pelletization. Waste to Energy, Resource conservation and recovery, Biological processing of Solid wastes.

Hazardous Wastes Management :Characteristics of Hazardous Waste, Management of Hazardous Waste; Chemical. Oxidation, vitrification, Hazardous wastes landfills, Radioactive waste; Detection and analysis, classification and disposal of Radioactive Wastes, Fly ash characteristics and disposal, Site remediation techniques.

UNIT - III

Effluents from power plants and Impact on environment – pollutants and pollution standards – Methods of Pollution control.

UNIT- IV

Industrial Safety: Accidents (Causes & Factors, Cost of Accidents, Accident Prevention, Investigation of Accidents, Reporting and Recording Systems for Accidents. First Aid (Basics of First Aid, How injuries are caused in lifting, falls etc.)

Fire Fighting: Fundamentals of Fire, Fire Fighting Equipments and Systems, Fire Extinguishing Methods, Demonstration of various Fire

UNIT - V

Industrial Hazards, Protective Clothing and Equipment, Safe Working Practices in Power Plant, Permit to work system, Safety in Movement and storage of Materials, House Keeping, Safety Rules.

REFERENCES:

1. Energy Management/Murphy WR, Mc Kay G/Butterworth Heinamn/2009
2. Environmental Engg: A Design Approach / Sincereo & Arcadio P/ PHI
3. Environmental Engineering: Water Supply, Sanitary Engineering and Pollution/ Kamala A Rao/TMH
4. Environmental Engineering/Dean J, Howard S/McGraw Hill/1985

**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech. – I Year – II Sem (Energy Systems)**

MODELLING AND SIMULATION LAB

WRITING PROGRAMS AND DEMONSTRATION

1. Declination of earth, hour angle, day length, local apparent time
2. Monthly average, hourly global and diffuse radiation on a horizontal surface and tilted surfaces.
2. Power generation from a wind turbine, Variation of wind velocity and power
3. with altitude
4. Solution of ordinary differential equations - 4th order R K Method
5. Solution of one-dimensional steady state heat conduction equation
6. Solution of two-dimensional steady state PDE
7. Solution of one-dimensional transient PDE

FINITE ELEMENT ANALYSIS

8. Two dimensional heat conduction
9. One dimensional transient heat conduction
10. Transient analysis of a casting process

CFD ANALYSIS

11. Flow through a pipe bend
12. Flow through a nozzle

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