Dhaka University of Engineering & Technology, Gazipur

Information Booklet

for

Postgraduate Program

Institute of Energy Engineering

Courses and Syllabus for Postgraduate Program

List of Courses

Course Code	Course Title	Credit	References
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Course Code	Symbol	Description	
1st two letters	EE	Energy Engineering	* Compulsory Course in suitable semester for all postgraduate programs and Results will be S/U
1st digit	7	Postgraduate Courses in EE	
2nd digit	Major field		
	0	Thesis/Project/Seminar/Fundamentals	** Compulsory Course for PGD program
	1	Energy Conservation and Management	
	2	Renewable Energy	S = Satisfactory
	3	Non Renewable Energy	U = Unsatisfactory
	4	Sustainable Energy	
	5	Energy Storage	
	6	Others	
Last two digits	01-10	Course Number	

Detailed Syllabus

Course Code	Course Title	Credit
EE 7000	**Thesis**	**18**
The research work as guided by the supervisor		
EE 7001	**Project**	**6**
The project work as guided by the supervisor		
EE 7002	**Seminar on Selected Topics**	**-**
The seminar topics will be selected by the respective supervisor		

Co- and tri-generation: Fundamentals, principles, technical options and factors influencing systems, performance parameters, case study.
Insulations and refractories: Purpose, types and applications, economic thickness of insulations, types and properties of refractories, industrial use of refractories, heat losses from furnace walls.
Energy performance assessment of heat exchangers: Fundamentals, terms and methodologies of performance assessment, case study.

EE 7103	Energy Efficiency in Electrical Systems	3

Fundamentals: Tariff and economic considerations, transmission and distribution losses, electrical load and demand management; role of power factor and improvement, electrical power systems analysis.
Energy assessment in electrical systems: *Motors*- Fundamentals and types, characteristics, efficiency, factors affecting energy efficiency, soft starters, variable speed drives; *Lighting systems*- Fundamentals; types, capacity selections, performance assessment; energy conservation opportunities; *Generators*- Fundamentals; types, capacity selections, performance assessment; energy conservation opportunities; *Transformer systems*- Fundamentals; types, capacity selections, performance assessment; energy conservation opportunities;
Control system: VFD; Microcontroller; PLC; soft starter; electronic ballast; inverter and charge controller.

EE 7104	Energy Efficiency in Mechanical Systems	3

Compressed air systems: Fundamentals; types of compressors, characteristics, performance, compressed air systems components, efficient operation of compressed air systems, systems capacity assessment, energy conservation opportunities.
HVAC and refrigeration systems: Components and systems; performance assessment of refrigeration plants, energy conservation opportunities.
Fans and blowers: Fundamentals; types, capacity selections, performance assessment; energy conservation opportunities.
Pumps and pumping systems: Types; system characteristic and curve; efficient operation and performance.
Cooling towers: Fundamentals; types, capacity selections, performance assessment; energy conservation opportunities.

EE 7105	Energy Management in Buildings	3

Indoor energy management: Processes in building; indoor activities and control, factors and characteristics on energy use and management, macro aspect of energy use, environmental requirement and management; thermal comfort, air quality and solar-generated desiccant dehumidification for ventilation, air-conditioning requirement, cooling and heating load, methods of control dynamic air-conditioning load; cooling coil load and air-conditioning load energy prediction.
Outdoor energy management: Visual perception, illumination requirement, auditory requirement climate, solar radiation and their influences; the sun-earth relationship; the energy balance on the earth's surface, climate, wind, temperature, sun shading; energy impact on the shape and orientation of buildings, end-use energy utilization and requirements; lighting and daylighting.
Building energy estimation: Status and estimation of energy use in building; heat gain and thermal performance of building envelope, steady and no steady heat transfer through the glazed window and the wall; standards for thermal performance and evaluation of the overall thermal transfer non-steady heat and moisture gain through building envelope; transfer function and finite-difference solution; energy balance concept and its implementation technologies for low energy buildings; application of radiant barriers with other building materials, radiant panel cooling, natural and active cooling with adaptive comfort, daylighting application heat gain through window; solar radiation transmission

through complex fenestration system, prediction of energy use by simple indicators and by building energy simulation, application of fuzzy logic and neural network for energy prediction.

EE 7201	Solar Photovoltaic Systems	3

Introduction: Photovoltaics, the physics behind the technology, the devices and practical applications, Photovoltaic cells, semiconductor physics, solar cell structures, their principle of operation, design and fabrication. Photovoltaic systems including power converters and energy storage, residential grid-connected photovoltaic systems.

Solar PV system components: Solar charge controllers and solar inverters-types and characteristics; solar cables; solar mounting system; solar PV system types -off grid, hybrid and on grid systems; solar photovoltaic applications; solar system performance measurement and monitoring; solar system operation and maintenance.

Integration of PV modules in architecture: BIPV basics, categories and type of buildings, steps in the design process with PV, urban aspects, practical rules for. integration, step-by-step design,

Design process: Strategic planning stand-alone PV systems; solar home systems, hybrid systems; photovoltaic water pumping utility interface PV systems; decentralized grid-connected PV systems; central grid-connected PV systems; standardization of interconnection requirements; PV system installation considerations; metering of PV system output; technical considerations for connecting to the grid; IEEE standard issues; national electrical code considerations and other issues.

Environmental impacts of photovoltaic systems: Environmental impacts due to manufacturing and operation of PV systems; land area required by PV systems; recycling of PV systems; recycling of crystalline silicon and amorphous silicon PV modules; recycling of compound semiconductor thin-film PV modules; energy demand for recycling of PV modules.

EE 7202	Solar Thermal Systems	3

Introduction: Sun-earth geometry relationship, variation of extraterrestrial radiation; beam and diffuse radiation; solar time and solar angle.

Flat plate collector: Construction methodology and classification; flat-plate energy balance equation, temperature distributions in FPC, collector overall heat transfer coefficient, testing of collector, collector efficiency factors; collector heat removal factor and flow factor, selective coating, effective transmittance-absorptance product, heat capacity effects in FPC; optimum inclination of FPC; evacuated tube cover collector, evacuated-tubular collector, evacuated tube of heat pipe.

Concentrating collectors: Fundamentals, characteristics parameters; concentration ratio; optical efficiency; classification of concentrators; tracking of concentrators, tracking methods; thermal analysis; materials for concentrators.

Applications: Solar water heating, heat collection in storage tank, effect of heat load; Solar cookers; Solar desalination; Solar dryers; Passive solar house heating and cooling; Solar refrigeration and air conditioning; Solar thermal energy storage; central receiver power plant; dish stirling systems; solar ponds.

Economic analysis: Net present value concept- investment with money from hand, investment with money from loan; life cycle cost method- residential systems, commercial systems; cost benefit comparison method, pay-back period method.

EE 7203	Solar Cell Operation and Technology	3

Introduction: History and development of solar cell technology, different generation of solar cell; solar photovoltaic basic, sunlight, semiconductor material for solar photovoltaic, electron-hole pair generation, recombination and the basic equation of device physics, carrier injections in photovoltaic p-n junction, dark characteristic, illuminated characteristic, solar cell output parameters, solar cell efficiency limits, losses and measurement, standard silicon solar cell technology, improved silicon cell technology, design of silicon solar cells, MIS solar cells, photo-electrochemical cells,

Thin film solar cell: CdTE, CIGS, CZTS, amorphous Si and CTS solar cells

EE 7204	Wind Energy Engineering	3

Wind resource assessment: History of wind energy, current status and future prospects, power available in wind; power and torque characteristics, types of wind turbine; characteristics of wind rotor; analysis of wind regimes; local effects, wind shear, turbulence and acceleration effects; measurement techniques of wind energy.

Wind speed statistics: Time and frequency distribution, mean wind speed and distribution of wind velocity; statistical model for wind data analysis - Weibull distribution; energy estimation of wind regimes, capacity factor.

Aerodynamics of wind turbine: Airfoil, lift and drag characteristics; aerodynamic theories, axial momentum theory, blade element theory, strip theory; power coefficient and tip speed ratio characteristics; rotor design and performance analysis.

Wind energy conversion system: Wind electric generators, tower, rotor, gearbox, power regulation, safety mechanisms, induction and synchronous generators; grid integration; wind pumps; wind driven piston pumps; limitations and performance analysis.

Environmental and economical aspect of wind energy system: Environmental benefits and problems of wind energy, economics of wind energy, factors influence the cost of energy generation; life cycle cost analysis.

EE 7205	Hydro Power Engineering	3

Introduction: Hydropower, water turbines, gradient, flow, force, power, energy and flow equations.

Hydro power plant: Fundamentals and classification of hydro power plants; status and prospect of hydropower; advantages and disadvantages of hydropower; site selection of hydroelectric plant; hydrological cycle, essential elements of a hydroelectric power plant.

Hydro power plant development: Run-of-the-river and storage schemes; diversion structures, power channels, desilting arrangements, forebay tank and balancing reservoir, penstock and power house; **v**arious types of turbines, suction tube, cavitation, hydraulic similarity, turbine characteristics; hydraulic solutions of impeller of Francis, Kaplan, Pelton and Bankiho turbines, impeller design, drawings and manufacturing technology; transmission and distribution system.

Environmental and economical aspect of hydro power: Environmental benefits and problems; cost structure analysis.

EE 7206	Bio-Energy Engineering	3

Fundamentals: Biomass resources; modes of biomass utilization for energy; routes of biomass conversion processes and biofuels production technologies; history and success stories of energy from biomass.

Characteristics of biomass fuels: Fuel analyses, sample preparation, characterization and chemical analyses; relevance of feed properties for anaerobic digestion and thermochemical processes.

Biomass feedstock preparation: Biomass feedstock dewatering and drying techniques, moisture content and conversion requirements, methods; size reduction; densification; and separation.

Thermochemical conversion: Pyrolysis- torrefaction, slow and fast pyrolysis, charcoal production; Gasification- fundamentals, fixed bed gasifiers; technical and operations problems with fixed bed gasifiers, fluidized bed gasifiers, entrained bed gasifiers, gas treatment.

Anaerobic-aerobic digestion: History of biomass digestion, types of biogas plants, kinetics and mechanism of high rate digesters for industrial waste water treatment, design, installation, operation and management of fixed dome and floating drum biogas plants, power generation from biogas plants, purification of biogas for grid quality methane/natural gas, digester effluent utilization strategies.

Combined heat and power production from biomass: Concept of CHP in energy production, poly-generation process (heat, electricity and chemical production), drawing up of mass and energy balances, evaluation of the techno- and eco-efficiency, economic evaluation/preparation of business plan.

EE 7207	Geothermal and Ocean Energy	3

Geology of geothermal regions: Fundamentals and strategical techniques of exploration, heat source systems for ambient air utilization and shallow geothermal utilization.
Geothermal well drilling: Design of up and down hole part system, district heating system, Environmental analysis of geothermal energy, case study.
Geothermal power plants: Single and double flash steam power plants, Binary cycle power plants, advanced geothermal energy conversion systems, exergy analysis applied to geothermal power systems.
Ocean energy: Fundamentals and principals of tidal and wave energy conversion; operation principal of ocean thermal energy conversion; future of ocean energy conversion.

EE 7208	Waste to Energy Conversion	3

Solid waste: Sources, types, compositions, properties of solid waste, collection, transfer stations, waste minimization and recycling of municipal waste.
Landfill method of solid waste disposal; Landfill classification; methods & siting consideration.
Layout & preliminary design of landfills: Composition, characteristics, generation; design of sanitary landfill, movement and control of landfill leachate & gases; Environmental monitoring system for landfill gases, gas recovery, applications.
Waste treatment & disposal size reduction: Incineration; furnace type & design; types of incinerators – fuel economy - medical / pharmaceutical waste / hazardous waste / nuclear waste incineration; Environmental impacts; measures of mitigate environmental effects due to incineration.
Biochemical conversion: Sources of energy generation, industrial waste, agro residues.
Anaerobic digestion: Biogas production; determination of BOD, DO, COD, TOC, & Organic loading, Aerobic & Anaerobic treatments, types of digester, factors affecting bio-digestion, activated sludge process. methods of treatment and recovery from the industrial waste water, case studies in sugar, distillery, dairy, pulp and paper mill, fertilizer, tanning, steel industry, textile, petroleum refining, chemical and power plant.
Rural applications of biomass: Combustion, chulhas, improved chulhas, biomass- physical and chemical composition, properties of biomass, TGA, DSC characterization, ash characterization.
Preparation of biomass: Size reduction, briquetting of loose biomass, briequtting machine.
Thermochemical conversion: Basic aspects of biomass combustion, heat of combustion, different types of grates, co-combustion of biomass; gasification - fixed and fluidized bed gasifier, gasification technologies for the selected waste like rice husk, coir pith, bagasse, poultry litter etc.; Pyrolysis.

EE 7301	Fuels and Combustion	3

Fuels: Fundamentals and classifications; present scenario and consumption; properties and various measurements; classification, composition, mining, preparation, washing and combustion of coal; coke making; exploration, evaluation, distillation, secondary processing of crude; refinery equipment; natural gas, LPG, producer gas and other fuel gases.
Chemical thermodynamics and flame temperatures: Heats of reaction and formation; free energy and the equilibrium constants; flame temperature calculations; sub- and supersonic combustion thermodynamics; combustion burners and furnaces; determination of calorific value of fuels and combustion air.
Chemical kinetics: Rates of reactions and their temperature dependence; simultaneous interdependent, chain and pseudo-first-order reactions with “fall-off" range; partial equilibrium assumption, flame phenomena in premixed combustible gases; structure, speed, stability limits of laminar flames; flame propagation through stratified combustible mixtures; turbulent reacting flows and flames; stirred reactor theory.
Detonation: Fundamentals; Hugoniot relations and hydrodynamic theory of detonations; ZND structure of detonation wave; structure of cellular detonation front and other detonation phenomena parameters; detonations in nongaseous media.

Diffusion flames: Gaseous fuel jets; burning in condensed phases, droplet clouds and convective atmospheres
Ignition: Fundamentals of chain spontaneous, thermal spontaneous, forced and other ignitions.
Environmental combustion considerations: Nature of photochemical smog; formation and reduction of NO_x and SO_x emissions; particulate formation; Stratospheric ozone.
Combustion of nonvolatile fuels: Fundamentals of carbon char, soot, and metal combustion; diffusional kinetics; diffusion-controlled burning rate; soot oxidation.

EE 7302	Natural Gas Engineering	3

Introduction: Natural gas-origin and development; natural gas properties- gas deviation factor, formation volume factor, gas density, compressibility, viscosity and heating value etc.; phase behavior of natural gas systems.
Gas reserve estimation methods: Volumetric, material balance (p/z), decline curve analysis etc., Darcy's law and its application for gas reservoir; gas well performance; deliverability and pressure-transient testing of gas wells; natural gas exploration, drilling, well completion and natural gas production.
Gas flow measurements and control: Methods of measurements, orifice meters- basic orifice meter equation, recording charts and flow rate calculation, critical flow prover etc.;
Natural gas processing: Gas and liquid separation, gas treating/sweetening, gas hydrates and dehydration of natural gas; gas compression; gas gathering and transportation; LPG and liquid hydrocarbon recovery; introduction to LNG, Gas-to-Liquids (GTL) and CNG technologies; global trade, overview of natural gas industries in Bangladesh; environmental aspects of the processing, production, distribution of natural gas, usage and gas disaster management.

EE 7303	Clean Coal Technologies	3

Introduction: Basic of clean coal technologies, coal reserves and its uses; coal liquefaction-process; catalyst preparation, characterization, hydrocracking/ hydrotreating reaction mechanism and kinetics.
FT (Fischer Tropsch) reactor overview: Reaction mechanism, kinetics syn gas production and composition, syn gas purification, and process parameters, Energy analysis/ Heat exchanger network optimization in FT synthesis.
Products refinery: Products analysis, and health safety and Environmental considerations; hybrid approach to synthesize liquid fuels, comparison of ICL and DCL.
Clean coal gasification: Process description, coal preparation, gasifier design, reaction kinetics, gas cleaning.
Integrated Gasification Combine cycle (IGCC): Process description, thermodynamic cycle, CO_2 pre combustion capture and storage, energy requirements.
Underground coal gasification (UCG): Important geological aspects for design consideration, channel formation b/w injection and production wells, process parameters/coal and rock properties, economics consideration.
Carbon capture techniques: Power generation technologies incorporating CO_2 Capture, CO_2 capture chemical processes.

EE 7401	Nuclear Power Plant Engineering	3

Introduction: Fundamentals and types of nuclear reaction; critical mass chain reaction; moderators; fundamentals, classifications, control and cooling of nuclear reactor; radiation damages; shielding of grays neutrons; materials for construction.
Nuclear power plant system: Fundamentals and layout design of nuclear power plant; containment buildings; primary containment vessels; structure of reactor core; mechanical stress in various structures; basic considerations in nuclear plant design; description and analysis of power plant systems and components including steam generator, steam dryer, separator, pressurizer, re-heater,

heat exchanger, condenser, demineralizer, pumps, turbine, generator, cooling tower; auxiliary cooling systems;
Control and safety system: Nuclear hazard analysis and control; fuel handling mechanisms; rad waste systems; electrical systems; reactor grid interface and load following.
Economic aspect: Components of nuclear power cost; economic comparison among nuclear, fossil fueled, dual and multipurpose nuclear plants; future trends in nuclear power cost.

EE 7402	**Advanced Power Plant Engineering**	**3**

Hydroelectric power plants: Rainfall and run-off measurements and plotting of various curves for estimating stream flow; design of reservoir and turbine; power plant design; construction and operation of different components of hydroelectric power plants; site selection; comparison with other type of power plants.
Steam power plants: Flow sheet and working of modern-thermal power plants; sub critical, super critical and ultra-super critical steam power plant; site selection; steam generator; case study.
Gas turbine power plants: Components and classifications; site selection and design of the plant; operation and performance analysis; case study.
Combined cycle power plants: Components and classifications; site selection and design of the plant; operation and performance analysis; case study.
Nuclear power plants: Principles of nuclear energy; nuclear fuel and reactors; operation and performance analysis; advantages and limitations of nuclear power station.
Engine based power plants: Fundamentals and components; advantages and limitations; operation and performance analysis; maintenance.

Waste heat recovery, cogeneration and tri-generation: Need, opportunities and present practice of waste heat recovery, cogeneration and tri-generation in power plants.
Renewable energy power plants: Construction and working of wind, tidal, solar photo voltaic (SPV), solar thermal, geo thermal, biogas and fuel cell power systems.
Fuels and waste management: Fuel types, storage, preparation and handling system; feeding and combustion; waste management.
Electric power generation and transmission: Generator, transformer, substation and transmission.
Power plant economics: Load curve; different terms and definitions; cost of electrical energy; tariffs methods of electrical energy; performance and operating characteristics of power plants; incremental rate theory; input-output curves; efficiency and heat rate; economic load shearing, load forecasting.

EE 7501	**Energy Storage Technologies**	**3**

Introduction: Need of energy storage; different modes of energy storage; fundamentals of traditional and modern bulk power system; principle of operation, layout and control, design tradeoffs of applying energy storage solutions throughout the transmission, sub-transmission and distribution networks; system impacts and effects of distributed generation on operation and control of bulk power system.
Electrochemical energy storage: Batteries - Fundamentals and types of battery storage; emerging battery technologies; comprehensive analysis of design considerations and application; impacts on system cost in terms of life cycle, environmental, and reliability of the end solutions.
Electro-magnetic energy storage: Super conducting magnetic energy storage (SMES)- Fundamentals and operations, theory of usage and emergent research, case study of large utility scale energy storage facilities; *Ultra-Capacitors* - Fundamentals, emerging technologies and applications including the usage in mobile applications, close proximity to the primary target market usage in renewable energy and power sources.
Mechanical energy storage: Pumped hydroelectric energy storage - Models for pumped hydro capacity and availability, system cost, capacity, conversion efficiency, case study; *Compressed gas*- Models for compressed gas capacity, efficiency and availability, system cost, conversion efficiency and siting barriers to adoption, possible applications in carbon capture and sequestration; *Flywheel* -

Models for flywheel capacity, availability, efficiency and self-discharge, applications in transportation.
Thermal energy storage: Fundamentals and applications of thermal energy storage including molten salts, cold reservoirs and phase change materials; analysis of design considerations, material selection, specific constraints and applications in renewable energy particularly utility scale solar and geothermal power production.
Advanced energy storage: *Fuel cell* - Principle of working, Basic thermodynamics and electrochemical principles, classification, electrolytes, fuel types, fuel cell electrodes; applications for power and transportation; *Hydrogen system* - Its merit as a fuel; production from fossil fuels, electrolysis, thermal decomposition, photochemical, photocatalytic, hybrid; *Storage:* Metal hydrides, metallic alloy hydrides, sea as the source of Deuterium.
System arrangement and application: Storage as grid component, storage with PV systems, hybrid power plant, fast charging stations, advanced system architecture, uninterruptible power supply (UPS).

EE 7502	**Hydrogen and Fuel Cells**	**3**

Hydrogen Energy: Hydrogen as a renewable energy source, Sources of Hydrogen, Fuel for Vehicles.
Hydrogen Production: Direct electrolysis of water, thermal decomposition of water, biological and biochemical methods of hydrogen production.
Hydrogen Delivery: Cryogenic liquid hydrogen delivery, Technical Challenges-Cost and Energy Efficiency, Hydrogen Purity Requirements, Hydrogen Leakage.
Hydrogen Storage: Gaseous, Cryogenic and Metal hydride.
Fuel cell: Fuel cell fundamentals, the alkaline fuel cell, acidic fuel cells, SOFC- emerging areas in fuel cells, fuel cell outlook, sources, comments, & revision history, applications –industrial and commercial.

EE 7601	**Energy Systems Modelling and Simulation**	**3**

Energy systems, modeling and simulations: Fundamentals and importance of modeling and simulation in energy systems; classification of modeling: physical model, mathematical model, management model.
Modeling overview: Steps in model development; nature of energy systems models and analysis, response of energy systems and their analysis.
Quantitative simulation techniques: Interpolation - polynomial, Lagrangian; curve fitting; regression analysis; solution of transcendental equations; system flow diagram and simulation.
Optimization: Objectives/constraints, problem formulation; linear programming - simplex tableau, pivoting, sensitivity analysis, dynamic programming, search techniques- univariate/multivariate.
Uncertainty analysis- probabilistic techniques; pinch analysis.
Energy-economy models: Scenario generation, input-output models, numerical solution of differential equations; transit analysis; analytics of system data modeling of electrical machines/loads, modeling of the grid synchronization and modulation techniques, smart grid modeling, energy modeling tools.

EE 7602	**Materials for Energy Application**	**3**

Materials for solar cells. Battery materials: Li-batteries, metal-hydrid-batteries. Materials for hydrogen technology: production (electrolysis), storage (hydrids), fuel cells. Phase change materials. Materials used in connection with gas power (catalysts, microporous materials, membranes). Nuclear materials, hard materials for oil/gas recovery, composites for wind energy, thermoelectric. Advanced materials for energy-efficient industry related applications: transportation, manufacturing and housing. Material use and recycling. Life-cycle assessment. Energy cost of materials. Economics of materials. Global materials flows.

EE 7603	Heating, Ventilation, Air Conditioning and Refrigeration Systems	3

Refrigeration systems: Fundamentals and basic terminology; pressure-enthalpy chart; types and applications of refrigeration systems; multistage, low temperature and alternative refrigeration systems; working principle of thermally driven cooling machines, single, double and triple effect absorption chiller, adsorption chiller; desiccant evaporative cooling; fundamentals, types and environmental aspects of refrigerants; design of refrigeration system.

Air-conditioning system: Conditions of indoor and outdoor air, comfort air conditions and comfort zone; indoor air quality; fundamentals and terminology of psychrometry; fundamentals and types of air conditioning system; functions and control of various components in central air conditioning plant; fundamentals, types and applications of air distribution system; air dust cleaning and bacteria removal.

Air-conditioning system design: CFM rating and tons of air conditioning of central air conditioning plant, cooling and heating loads, calculation procedures, duct sizing and piping design, pumps and fans selection, air ventilation, calculation of fresh air supply of multi-story buildings, forced convection based air ventilator design; building management system.

Cooling towers: Fundamentals and types of cooling towers; design and performance of cooling tower, hydronic terminal units.

EE 7604	Energy Smart Transport Vehicle	3

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance.

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.

Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

EE 7605	Instrumentation in Energy Systems	3

Introduction: Fundamentals and types of energy system; materials for instrumentation and measurements; fundamentals, classifications and characteristics of transducers; transient analysis of a control system.

Temperature measurement: Bimaterials, pressure thermometers, thermocouples, RTD, thermisters, and pyrometry, pyrometers- calibration of pressure measuring equipment.

Flow Measurement: Variable head flow meters- Rota meters, electromagnetic flow meters, hot wire anemometers, hot film transducers, ultrasonic flow meters.
Air pollution and miscellaneous measurements: Particulate sampling techniques, SO_2, combustion products, opacity; odour measurements - measurement of liquid level, humidity, O_2, CO_2 in flue gases- pH measurement moving iron/coil, energy measurement, power factor meter-analog signal conditioning, amplifiers, instrumentation amplifier, A/D and D/A converters, digital data processing and data acquisition system.

EE 7606	**Project Planning and Management**	**3**

Project Planning: Project analysis; market analysis; demand analysis; technical analysis; financial analysis; social cost benefit analysis; risk analysis; project cash flow; appraisal criteria; operation and flexibility.
Implementation-network technique for project management: PERT; CPM; resource scheduling; resource leveling; project monitoring; case studies using PERT/CPM methodology.

EE 7607	**Advanced Numerical Computation and Analysis**	**3**

Error analysis; Solution of algebraic and transcendental equations;
Method of undetermined co-efficient: Algorithm and computer programming for computing the n-number of system of linear equations with n-unknowns by direct and iterative techniques, Numerical Solution of Polynomial equation by computer programming iterative method.
Ordinary differential equations: Initial value problems of linear and non-linear system of equations; Finite-difference technique of solving ordinary differential equations; Multi-segment method of solving unstable system of equations.
Partial differential equations: finite difference method of solving of both the linear and non-linear partial differential equations.
Numerical Differentiation and Integration:
Eigen Values and Eigen Vectors: Orthogonal and orthonormal sets, The Gram-Schmidt orthogonalization process, Sturm–Liouville theory, Optimization (Linear and No-linear programming).

EE 7608	**Research Methodology**	**3**

Educational research: Meaning, aims, nature and scope of educational research, characteristics and prerequisites of educational research, types of educational research, research needs in different subjects of education.
Research problem: Meaning of research problem, sources of research problem, criteria / characteristics of a good research problem, errors in selecting a research problem.
Methods of educational research: Qualitative research, phenomenological studies, ethnographical studies, case studies, historical studies, philosophical studies; quantitative research, experimental research, quasi experimental research, surveys, correlation studies, action research.
Developing a research proposal: Format of research proposal, individual research proposal, and institutional proposal.
Hypothesis: Meaning, types of hypothesis.
Sampling: Sampling and population, techniques sampling selection, characteristics of a good sample, sampling errors and how to reduce them.
Tools and techniques of data collection: Checklist, data schedule, observation, opinionnaire, interview, sociometric techniques, questionnaire, rating scales, interview schedules, reliability and validity of various tools and techniques.
Research Report: Format of the research report, style of writing the report, references and bibliography; evaluation of research, criteria of evaluation.

EE 7609	**Energy Policy and Economics**	**3**

Introduction: Natural resources, classification, importance, role of natural resources in economic development; energy resources, types and properties of energy, forms of energy.

Emergence of energy economics: Scope and nature, energy indicators, energy economics and its relations with other branches.
Energy and development: Role of energy in economic development, energy intensity and energy elasticity; national and international comparison; low, middle, and high income economies; role of international institutions - OPEC, OAPEC, IEA, and world bank.
Energy and environment: Energy crisis and environmental crisis- causes and consequences, remedial measures; impact of energy consumption and production on environment with illustrations; role of energy and environmental economists in solving energy the crises.
Energy conservation and energy management: Energy planning and energy conservation - meaning, objectives and importance; energy management - meaning, objectives and importance; recent developments; energy auditing; energy accounting; energy pricing and taxes; role of economists in promoting sustainable energy management.
Bangladesh energy profile: Energy sector of Bangladesh, organizational structure, energy supply (coal, lignite, oil, gas and powers - hydro, nuclear, thermal); energy demand (agriculture, industry, transport, domestic, etc.); renewable energy sources and technology (solar, wind, biogas, biomass, geothermal, OTEC, tidal, wave hydrogen, fuel cell, bio-diesel); renewable energy programmes; energy under five year plans; energy issues and policy options for Bangladesh.