RENEWABLE ENERGY ENGINEERING (RNEE) PROGRAM

Mission

The mission of the Renewable Energy Engineering program is to prepare experts in the various aspects of energy and alternative energy sciences and technologies, in particular energy conservation strategies and engineering practices for clean energy production. The program is devoted to offer a high-quality learning experience for students by applying prominent educational methods that build strong theoretical grounding and outstanding hands-on skills, and cultivate a sense of responsibility toward the profession, society and environment.

Program Educational Objectives

The educational objectives of the RNEE program are determined to support professional development of the graduates where they are expected to:

- PEO1: demonstrate competency to handle complex engineering tasks and provide professional solutions in the fields of renewable energy and thermal systems through integration of analytical, experimental, and computer knowledge.
- PEO2: demonstrate ability to pursue graduate studies in renewable energy engineering and related multidisciplinary areas.
- PEO3: demonstrate professional leadership in their fields of expertise and service to local and international communities.

Student Outcomes

Upon completion of the program, graduates shall have developed:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Degree Requirements

The undergraduate curriculum for the degree of Bachelor of Engineering in Renewable Energy Engineering consists of 150 credit-hours of course work + IC3 (Internet and Computing Core Certification) + 30 credits transferred from Lebanese Baccalaureate or equivalent, where the standard duration of study is 4 years including three summer terms.

Career Opportunities

Renewable energy engineers acquire a broad spectrum of skills needed for every profession in the energy industry that is booming worldwide. Jobs requiring renewable energy engineering skills include: energy sustainability, clean power generation and distribution including solar energy systems, wind energy systems, hydropower plants, and geothermal energy systems, energy efficiency in buildings, energy system modelling, and energy audit. Also, renewable energy engineering graduates will have prominent chances to work in research and development spending huge budgets on green energy studies.

Program Overview

The renewable energy engineering (RNEE) program is a four-year program that consists of 150 credits and aims at educating engineers to acquire the necessary competencies to design, build and operate the green energy infrastructure. In addition to basic science and math, the program begins by building, over four semesters, solid grounding in engineering fundamentals comprising elements from material, mechanical, thermal, and electrical engineering. This is followed by four semesters of advanced engineering courses that cover solar energy, photovoltaic cells, wind energy, geothermal energy and heat pumps and hydropower generation. In addition, the RNEE program offers several courses in energy storage and energy conservation such as Building Energy Auditing, Building energy modeling, Green buildings and LEED as well as Energy Management.

The curriculum includes several courses with experimentation and/or design projects. Taken together, these courses provide students with strong theory and practical hands-on enabling them to devise effective solutions for the generation, distribution, and utilization of green energy for grid-connected and off-grid applications. The major culminates in a two-semester capstone where students, working in small groups, demonstrate their mastery of the required engineering competencies and the design process.

The student's study plan is given to every RNEE student upon his/her enrollment. The RNEE curriculum consists of the following components:

I. Common Requirements	**Credits**
A. General Education Requirements	17
B. Basic Sciences and Mathematics	30
C. General Engineering Topics	15
II. RNEE Program-Specific Requirements	**Credits**
A. Engineering Topics from Outside the Major	20
B. Renewable Energy Engineering Major	51
C. Renewable Energy Engineering Technical Electives	12
D. Final Year Project	4
E. Internship	1

I. Common Requirements

A. General Education Requirements

The list of General Education Requirements courses and their descriptions are presented in the introductory pages of the Faculty of Engineering section in this catalog.

B. Basic Sciences and Mathematics

The Basic Sciences and Mathematics component includes 30 credits distributed as follows:

Course	Title	Credits	Prerequisite
CHEM 241	Principles of Chemistry	3	
CHEM 247	Electrochemistry	2	Pre: CHEM 241
CHEM 247L	Electrochemistry Lab	1	Pre or Co: CHEM 247
MATH 281	Linear Algebra	3	

MATH 282	Calculus	3	
MATH 283	Differential Equations	3	Pre: MATH 281 and MATH 282
MATH 284	Numerical Analysis	3	Pre: MATH 283
MATH 381	Probability and Statistics	3	Pre: MATH 282
MATH 380	Discrete Mathematics	3	Pre: MATH 282
PHYS 280	Classical Physics	3	
PHYS 281	Electricity and Magnetism	3	

Descriptions of the required mathematics and basic sciences courses are presented in the introductory pages of the Faculty of Engineering section in this catalog.

C. General Engineering Topics

The General Engineering component includes 15 credits distributed as follows:

Course	Title	Credits	Prerequisite
COMP 208	Programming I	3	-
CVLE 210	Statics	3	-
INME 221	Engineering Economy	3	-
MCHE 201	Engineering Drawing and Graphics	3	-
MCHE 213	Dynamics	3	-

Descriptions of the General Engineering Topics are given below:

COMP 208 PROGRAMMING I (3Crs.: 2Lec, 2Lab) Computer fundamentals. Computer system components: hardware and software. Problem solving and flowcharts/pseudocode. High level programming: data types, structured programming constructs, input and output, expressions and assignments, selection, repetition, arrays.

CVLE 210 STATICS (3Crs.: 3Lec, 0Lab) Force vectors (analytical and graphical methods), free-body diagrams; equilibrium of particles and rigid bodies in two and three dimensions; structural elements and supports; plane and space trusses; axial, shear, and moment diagrams of beams; Cable-supported structures. Friction; center of gravity and centroid; moment of inertia. Applications.

INME 221 ENGINEERING ECONOMY (3Crs.: 3Lec, 0Lab) Basics principles and techniques of economic analysis of engineering project, time value of money, cost allocation and estimation, evaluation of engineering projects and investments, depreciation, inflation, bond and loan financing, after tax cash flow analysis, sensitivity analysis, selection among mutually exclusive alternatives using present worth, annual worth, internal rate of return, benefit-cost.

MCHE 201 ENGINEERING DRAWING AND GRAPHICS (3Crs.: 2Lec, 2Lab) Constructional Geometry-constructing tangents. Plane curves and polygons. Orthographic drawing and theory of sketching shapes and surface identification. Orthographic projection of views. Sectional views and conventions. Pictorial drawing. Applications of Auto-CAD software for 2D drawings.

MCHE 213 DYNAMICS (3Crs.: 3Lec, 0Lab) Dynamics of a particle, system of particles, and planar rigid bodies using Newton's law of motion. Work and energy principle, impulse and momentum principle. Free-body diagram and concept of equilibrium. Planar motion and kinematics of rigid bodies.

II. RNEE Program-Specific Requirements

A. Engineering topics from outside the major

This part of the RNEE curriculum includes 20 credits offered by other engineering programs. These courses are listed in the table below.

Course	Title	Credits	Pre-/Co-requisites
POWE 211	Electric Circuits (for Mechanical Engineering students)	3	Pre: PHYS 281
POWE 282	Power Electronics	2	Pre: POWE 211
POWE 282L	Power Electronics and Solid State Drives Lab	1	Pre or Co: POWE 282
POWE 381	Electromechanical Conversion Systems	3	Pre: POWE 211
POWE 385	Modern Drives	2	Pre: POWE 381
POWE 382	Power System Operation, Protection & Analysis	3	Pre: POWE 381
POWE 481	Grid Integration	3	Pre: POWE 382
POWE 482	Photovoltaic Systems	3	Pre: POWE 282

Descriptions of this group of courses are given below.

POWE 211 ELECTRIC CIRCUITS (for Mechanical Engineering students) (3Crs.: 3Lec, 0Lab): Circuit variables. Ohm's law. Kirchhoff's laws. Series and parallel resistors. Voltage and current divider circuits. Delta-to-Wye transformation. Node-voltage method. Mesh-current method, Thevenin equivalent circuit. Operational amplifiers. Sinusoidal steady-state analysis and power computations. Balanced-three phase circuits. Passive and active filter circuits. ***Pre-req.: PHYS 281.***

POWE 282 POWER ELECTRONICS (2Crs.: 2Lec, 0Lab): Power Switches: Diodes, Thyristor, Triac, GTO, BJT, MOSFET, IGBT. AC to DC conversion (Rectifying circuits: single-phase and three-phase, uncontrolled, fully controlled rectifiers). DC to DC conversion (buck boost system). ***Pre-req.: POWE 211.***

POWE 282L POWER ELECTRONICS AND SOLID STATE DRIVES LAB (1Cr.: 0Lec, 2Lab): Experimental work related to the topics discussed in POWE 282. ***Pre or Co: POWE 282.***

POWE 381 ELECTROMECHANICAL CONVERSION SYSTEMS (3Crs.: 3Lec, 0Lab): Magnetic circuits, single-phase and three-phase transformers, DC motors and generators, synchronous generators, three-phase induction motors and generators. ***Pre-req.: POWE 211.***

POWE 382 POWER SYSTEMS OPERATION, PROTECTION, AND ANALYSIS (3Crs.: 3Lec, 0Lab): General view of power system structure (power generation, transmissions, and distribution). Per unit systems, fault analysis, load flow analysis, economic dispatch and introduction to stability. Protective relays principles, fuse, circuit breakers and protection schemes. Protection of induction motors including over speed, phase sequence and lose of excitation protection. ***Pre-req.: POWE 381.***

POWE 385 MODERN DRIVES (2Crs. 2Lec, 0Lab): Concept, classification, parts and advantages of electric drive system. Fundamental torque and moment of inertia equations, Equivalent value of drive parameters for loads with rotational and translational motion. Overview of classical drives. Modern drive of DC motors (Single phase, three phases fully controlled and half controlled DC drives 1,2, and 4-quadrant drive circuits). Modern drive of Induction motors (Stator voltage variation by three phase controllers, Speed control using chopper resistance in the rotor circuit, slip power recovery scheme. Pulse width modulated inverter fed induction motor drive. Volts/Hertz drive technique) ***Pre-req.: POWE 381.***

POWE 481 GRID INTEGRATION (3Crs.: 3Lec, 0Lab): This course presents the analytical framework used to evaluate the power system with high penetration levels of several renewable energy. It also elaborated

the system operations improvements and the planning of gird integration. ***Pre-req.: POWE 382.***

POWE 482 PHOTOVOLTAIC SYSTEMS (3Crs.: 3Lec, 0Lab): This course introduces photovoltaic (PV) systems, covering fundamental concepts, design, and application. Mechanical integration of solar panels. Students will learn about solar radiation, system components, and the design and installation of PV systems. Emphasis is placed on both stand-alone and grid-connected electrical systems. The course also includes economic analysis and the use of PV systems design software. ***Pre-req.: POWE 282.***

B. Renewable Energy Engineering Major

The Renewable Energy Engineering major courses are listed in the table below.

Course	Title	Credits	Pre-/Co-requisites
RNEE 201	Fundamentals of Renewable Energy	2	-
RNEE 322	Green Buildings and LEED	3	Pre: RNEE 201
RNEE 431	Wind Energy	3	Pre: MCHE 331
RNEE 521	Building Energy Modeling	3	Pre: RNEE 322 and MCHE 422
RNEE 525L	Renewable Energy Lab	2	Pre or Co: RNEE 521
RNEE 526	Solar Thermal Energy Systems	3	Pre: MCHE 421
MCHE 315	Instrumentation and Measurement	2	Pre: MATH 381 and (MCHE 214 or POWE 282)
MCHE 315L	Instrumentation and Measurement Lab	1	Pre or Co: MCHE 315
MCHE 321	Thermodynamics I	3	Pre: PHYS 280 or PHYS 282
MCHE 331	Fluid Mechanics I	3	Pre: PHYS 280 or PHYS 282
MCHE 341	Mechanics of Materials for RNEE	3	Pre: CVLE 210
MCHE 342	Mechanical Design for RNEE	3	Pre: MCHE 201 and MCHE 341
MCHE 418	Dynamic Systems	3	Pre: MATH 283
MCHE 421	Heat Transfer	3	Pre: MATH 284 and MCHE 321
MCHE 422	Refrigeration and Air Conditioning	3	Pre: MCHE 421
ENGR 500	Research Methodology	2	Pre: ENGL 211
MCHE 515	Control Systems	2	Pre: MCHE 418
MCHE 515L	Control Systems Lab	1	Pre or Co: MCHE 515
MCHE 526	Energy Management	3	Pre: MCHE 321
MCHE 533	Hydraulic Machinery and Stations	3	Pre: MCHE 331

Description of Major Courses

RNEE 201 FUNDAMENTALS OF RENEWABLE ENERGY (2Cr.: 2Lec, 0Lab): Overview of the main renewable energy sources including solar energy, wind energy, geothermal energy, hydro-energy, bio fuel and biomass, hydrogen and fuel cells. Heat transfer basic fundamentals, Energy analysis, and engineering economy and environmental impact of utilization of renewable energy systems will be also discussed.

RNEE 322 GREEN BUILDINGS AND LEED (3Cr.: 3Lec, 0Lab): Concept and design of green buildings through minimizing resource consumption, increasing energy efficiency, and reducing life cycle costs. Practical sustainable measures for building's location and transportation, natural lighting, energy storing material, insulation efficiency, water efficiency, energy and atmosphere, construction materials and resources, maintaining good indoor environmental quality, passive and innovative design. Focus on LEED (Leadership in Energy and Environmental Design). Preparation for LEED Green Associate Exam. ***Pre-req.: RNEE 201.***

RNEE 431 WIND ENERGY (3Cr.: 3Lec, 0Lab): Overview of the fundamentals of wind turbine: history, characteristics and impact. Physics of wind power. Vertical and horizontal axis turbines. Aerodynamics of wind turbines. Wind turbine technology and components, wind turbine installation, Wind resource

assessment, Wind turbine blades design, Wind energy industry from component design to electric generation and transmission. Commercial development, economics and environmental impacts. ***Pre-req.: MCHE 331.***

RNEE 521 BUILDING ENERGY MODELING (3Cr.: 3Lec, 0Lab): Hourly simulation of the building's interior loads and the heat transmission through building's envelope, solar glazing/shading impact, infiltration and ventilation. Creating the building model using commercial software, such as Design Builder, to evaluate the impact of HVAC, hot water and lighting systems on the annual energy consumption. Modeling and computational simulation of building energy system components such as chillers, solar panels, solar collectors, boilers, and heat recovery systems. ***Pre-req.: RNEE 322 and MCHE 422.***

RNEE 525L RENEWABLE ENERGY LAB (2Cr.: 0Lec, 4Lab): Testing of Photovoltaic or solar cells: identifying the characteristics of solar modules and their optimum alignment. Experimental investigation of various types of wiring and connection configurations for solar modules. Tests on wind power plants: operating the generator with varying wind force levels and regulating the output voltage and frequency, and finding the optimum operating points under changing wind conditions. Testing the performance of renewable energy power plants such as hydroelectric and biofuel power plants. Testing the distribution and transmission of the electrical power generated from renewable energy power plants. ***Pre or Co: RNEE 521.***

RNEE 526 SOLAR THERMAL ENERGY SYSTEMS (3Cr.: 3Lec, 0Lab): Study of the different heat transfer mechanisms, principles of solar thermal engineering. Overview on low- and high-temperature solar thermal energy collectors (design and installation), medium and high solar thermal plants (thermal analysis and design), thermal energy storage, solar space air heating, and solar cooling systems (absorption) analysis. Solar energy utilization for desalination technology. Sizing and simulating solar domestic and industrial applications of hot water supply. ***Pre-req.: MCHE 421.***

MCHE 315 INSTRUMENTATION AND MEASUREMENT (2Cr.: 2Lec, 0Lab): Elements of a measurement system. Classification of sensors. Sensor characteristics. Sensor types. Statistical analysis of data, curve fitting, and uncertainty analysis. Physical principles. Interfacing concepts - amplification, filtering, A/D conversion. ***Pre-req***.: ***MATH 381 and (MCHE 214 or POWE 282).***

MCHE 315L INSTRUMENTATION AND MEASUREMENT LAB (1Cr.: 0Lec, 2Lab): Introduction to LABVIEW. Experiments to measure various physical quantities. Data acquisition and analysis using NI-ELVIS platform. Typical laboratory experiments involve building signal conditioning circuits for thermocouples, thermistors, photodiodes, strain gauges, accelerometers, etc. Team project to design and develop a measurement system***. Pre or Co: MCHE 315.***

MCHE 321 THERMODYNAMICS I (3Crs.: 3Lec, 0Lab): Introduction and basic concepts. Properties of pure substances. Energy analysis of closed systems. Mass and energy analysis of control volumes. Second law of Thermodynamics. Heat engines and Carnot cycle. Refrigerators and heat pumps. Entropy. Gas power cycles. Vapor refrigeration cycles. ***Pre-req.: PHYS 280 or PHYS 282.***

MCHE 331 FLUID MECHANICS I (3Crs.: 3Lec, 0Lab): Introduction to Fluid Mechanics, Fluid properties, Fluid static, Forces on immersed surfaces, buoyancy and stability of floating bodies, fluid masses subjected to acceleration, vortex motion. Basic fluid dynamic equation, Continuity equation, Bernoulli's equation, Bernoulli's equation application. Fluid flow in pipelines, pipe losses, major and minor losses calculation, series and parallel pipes. ***Pre-req.: PHYS 280 or PHYS 282.***

MCHE 341 MECHANICS OF MATERIALS FOR RNEE (3Cr.: 3Lec, 0Lab): Introduction to the mechanics of deformable bodies considering linear material response. Load-stress, stress-strain, and strain-displacement relations. Tension/compression of rods and trusses, torsion of shafts, bending in beams, bucking of columns, and pressure vessels. Analysis of combined loading. Mohr circle analysis. Stress-strain transformations. Statically indeterminate structures. ***Pre-req.: CVLE 210.***

MCHE 342 MECHANICAL DESIGN FOR RNEE (3Crs.: 3Lec, 0Lab): Overview of the mechanical design process. Analytical concepts and tools for the design of machine elements. Failure theories. Design for strength under static and fatigue loading. Design for rigidity. Design of shafts. Design of non-permanent

joints (fasteners and keys) and power screws. Design of permanent joints: rivets, welds and adhesive joints. Design of mechanical springs. Computer aided applications. ***Pre-req.: MCHE 201 and MCHE 341.***

MCHE 418 DYNAMIC SYSTEMS (3Crs.: 3Lec, 0Lab): Introduction to dynamic modeling of mechanical, electrical, thermal and fluid systems. State-space equations. Analysis of linear systems. Time- and frequency-domain analysis. Laplace transform techniques. Nonlinear systems. Introduction to dynamic systems characteristics and performance. Simulation using Matlab and Simulink. ***Pre-req.: MATH 283.***

MCHE 421 HEAT TRANSFER (3Crs.: 3Lec, 0Lab): Concepts and laws of conduction, convection and radiation heat transfer and their application to solving engineering thermal problems. Steady and transient heat conduction. Heat generation. Extended surfaces. External and internal forced convection of laminar and turbulent flows. Natural convection. Thermal radiation, view factors, and radiation exchange between gray bodies. ***Pre-req.: MATH 284 and MCHE 321.***

MCHE 422 REFRIGERATION AND AIR CONDITIONING (3Crs.: 3Lec, 0Lab): Refrigeration introduction and fundamentals, Basic refrigeration cycles, different types of central/unitary air conditioning systems (DX-unit, chillers, and VRV systems). Psychrometric air properties, air-conditioning processes, air conditioning cycles analysis. Fundamentals of HVAC system design, cooling/heating load estimation, analysis of applied psychrometrics charts, schematic design of HVAC system, equipment selection, Refrigeration cycles, multi-stage compression cycles, compressor types and selection, metering device selection, evaporator selection and design, condenser selection and design. Basic cycle performance, suction accumulator. Liquid receiver, oil separator, multi evaporators design, and different defrost methods. Cold store design. Noise criteria and analysis. ***Pre-req.: MCHE 421.***

ENGR 500 RESEARCH METHODOLOGY (2Crs.: 2Lec, 0Lab): Steps for conducting a successful research: formulating a research problem, conceptualizing a research design, constructing an instrument for data collection, writing a research proposal, collecting data, processing & displaying data, writing a research report. ***Pre-req.: ENGL211.***

MCHE 515 CONTROL SYSTEMS (2Crs.: 2Lec, 0Lab): Transfer function for various dynamic systems. Block reduction techniques. Performance of first-, second-, and higher-order systems. Steady-state error. Stability analysis and Routh-Hurwitz criterion. Root-locus techniques. Design of controllers and compensators. Frequency response and Bode plots. ***Pre-req.: MCHE 418.***

MCHE 515L CONTROL SYSTEMS LAB (1Cr.: 0Lec, 2Lab): Analysis of various control systems in Matlab and Simulink. Design of PID controllers using the control toolbox. Control experiments that includes: DC Motor and inverted pendulum. Team project. ***Pre or Co: MCHE 515.***

MCHE 526 ENERGY MANAGEMENT (3Crs.: 3Lec, 0Lab): The course introduces the concepts and techniques of energy management and conservation based on the national statistics of energy supply and demand. Scope of the energy problems and approaches to provide solutions; energy auditing; improving energy utilization in space conditioning and steam, hot water and compressed air systems; energy savings opportunities in refrigeration and cooling systems; insulation; lighting efficiency technique, use of waste thermal energy systems for domestic and industrial applications, and electrical energy conservation are highlighted. ***Pre-req.: MCHE 321.***

MCHE 533 HYDRAULIC MACHINERY AND STATIONS (3Crs.: 3Lec, 0Lab): Introduction to water turbines. Types of Hydraulic turbines, Pelton wheel, Francis, propeller and Kaplan turbines, construction, design factors, discharge regulation and part load performance, velocity diagram, power, efficiency, model testing, cavitations and turbine selection, pump storage projects, mini-water turbines. Hydro-power plants in Lebanon. ***Pre-req.: MCHE 331***

C. Renewable Energy Engineering Technical Electives

The RNEE curriculum includes four 3-credit hour courses as technical electives. The courses are chosen from the courses listed in the table below with their descriptions given thereafter.

Course	Title	Credits	Pre-/Co-requisites
RNEE 522	Geothermal Energy & Heat Pump Applications	3	Pre: MCHE 321
RNEE 540	Biofuel and Biomass	3	Pre: MCHE 321
RNEE 541	Fuel Cells	3	Pre: CHEM 247
RNEE 543	Wave and Tidal Energy	3	Pre: MCHE 331
RNEE 544	Renewable Energy Transportation Systems	3	Pre: MCHE 321
RNEE 545	Hybrid and Electric Transportation	3	Pre: MCHE 214 or POWE 282
RNEE 546	Building Energy Auditing	3	Pre: MCHE 421
RNEE 547	Environmental Pollution and Emission Control	3	Pre: MCHE 315
RNEE 548	Ceramic Materials for Renewable Energy	3	Pre: PHYS 280 or PHYS 282
MCHE 322	Thermodynamics II	3	Pre: MCHE 321
MCHE 332	Fluid Mechanics II	3	Pre: MCHE 331
MCHE 514	Programmable Logic Controllers	3	Pre: MCHE 315
MCHE 523	Thermal Equipment Design	3	Pre: MCHE 421
MCHE 529	Thermal Power Stations	3	Pre: MCHE 421
MCHE 531	Pump Technology	3	Pre: MCHE 332
MCHE 535	Hydraulic Circuits	3	Pre: MCHE 331
MCHE 540	Fluid Thermal System Design	3	Pre: MCHE 531
MCHE 562	Sensors and Actuators	3	Pre: MCHE 315
MCHE 564	Automotive Engineering	3	-
MCHE 565	Technology Ventures	3	Pre: INME 221
MCHE 566	Automotive Control	3	Pre: MCHE 564
MCHE 571	Refrigeration and HVAC Applications	3	Pre: MCHE 422
MCHE 572	Water Desalination Technologies	3	Pre: MCHE 421
MCHE 573	Operation and management of Thermal Power Stations	3	Pre: MCHE 529 or MCHE 521
MCHE 575	REVIT MEP For Mechanical Engineers	3	Pre: MCHE 422
MCHE 581	Computational Fluid Dynamics	3	Pre: MCHE 421 and MCHE 332

Description of Technical Elective Courses

RNEE 522 GEOTHERMAL ENERGY AND HEAT PUMP APPLICATIONS (3Cr.: 3Lec, 0Lab): Study of the different heat transfer mechanisms, Thermodynamic analysis review, this course presents the role of geothermal energy as a renewable energy, and a broad understanding of the fundamental design and operational aspects of projects harnessing geothermal energy to provide heating, cooling, and hot water for residential and light commercial applications.The course including the demonstration of steam cycles for geothermal applications (thermodynamic analysis and simulation). This course also introduces the geothermal heat pump, its importance and applications. ***Pre-req.: MCHE 321.***

RNEE 540 BIOFUEL AND BIOMASS (3Crs.: 3Lec, 0Lab): Fundamental concepts of biofuels and biomass energy systems, their production, availability, types of biomass derived fuels and energy. Thermochemical conversion of biomass to heat, power and fuel; biochemical conversion of biomass to fuel and case studies on biofuel production. ***Pre-req.: MCHE 321.***

RNEE 541 FUEL CELLS (3Crs.: 3Lec, 0Lab): Hydrogen properties, uses, safety and fuel cell technologies. Types of fuel cells. Introduction to hybrid electric vehicles. ***Pre-req.: CHEM 247.***

RNEE 543 Wave and Tidal Energy (3Crs.: 3Lec, 0Lab): Overview of the fundamentals of wave and tidal energy: history, characteristics and impact. Physics of wave and dynamic tidal power. Marine resources

assessment. Wave energy technologies: oscillating water columns, overtopping systems, and oscillating devices. Tidal energy mechanisms: stream, barrages and lagoons. Wave energy convertors. Wave and tidal power generation and transmission. Commercial development, economics and environmental impacts. ***Pre-req.: MCHE 331***

RNEE 544 RENEWABLE ENERGY TRANSPORTATION SYSTEMS (3Crs.: 3Lec, 0Lab): Renewable energy transportation systems including fuel cells, hybrid gasoline-electric engines, electric vehicles, bio-diesel, flex-fuel vehicles, high-efficiency diesel engines, gas turbine prime-mover systems. Topics include fuel-air mixing, fuel storage, fuel delivery, cooling, fuel leak detection, chemical safety, and electrical power control systems. ***Pre-req.: MCHE 321.***

RNEE 545 HYBRID AND ELECTRIC TRANSPORTATION (3Crs.: 3Lec, 0Lab): Fundamentals of hybrid electric and battery electric transportation systems with particular emphasis on automotive vehicles. Introduction to various concepts and terminologies, the state-of-the-art development, energy conversion and storage options, modeling, analysis, system integration and basic principles of vehicle controls. Basic powertrain configurations of Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV), and Battery Electric Vehicle (BEV). Principal elements of these powertrain: battery, electric motor, engine, and transmission. Fundamental design concepts for HEV/ PHEV and BEV powertrain. Efficient methods of component sizing via appropriate modeling and analysis methodologies. In-depth coverage for the energy and power management of HEV/PHEV and BEV powertrain. ***Pre-req.: MCHE 214 or POWE 282.***

RNEE 546 BUILDING ENERGY AUDITING (3Crs.: 3Lec, 0Lab): Evaluating building thermal/electric/process loads including lighting, hot water, HVAC and central plant systems, industrial refrigeration and motors. Opportunities for managing energy use through controls and operations/maintenance strategies. Roles of commissioning, energy auditing, renewables and economic analysis in reducing energy use. ***Pre-req.: MCHE 421.***

RNEE 547 ENVIRONMENTAL POLLUTION AND EMISSION CONTROL (3Crs.: 3Lec, 0Lab): Environmental pollution sources and fundamental mechanisms of their impact on the environment and human health. Measurement and control of automotive emissions, in particular diesel particulate matter. Topics in emission control technologies including sensors, control mechanisms, and remedial systems. All topics are to be combined all together into a course project. ***Pre-req: MCHE 315.***

RNEE 548 CERAMIC MATERIALS FOR RENEWABLE ENERGY (3Crs.: 3Lec, 0Lab): Fundamental concepts of ceramic materials. Atomic structure, bonding the transport of charged defects and their relationships to conductivity in ceramics, phase diagrams and glasses. Solid state processes, including sintering and grain growth. Physical properties including mechanical, thermal, magnetic, dielectric, and optical properties. Application to renewable energy productions. ***Pre-req.: PHYS 280 or PHYS 282.***

MCHE 322 THERMODYNAMICS II (3Crs.: 3Lec, 0Lab): Ideal and actual vapor power cycles. Rankine cycle parameters impact. Reheat and regenerative steam power cycles. Co-generation cycle concept. Steam flow through nozzles and turbines. Gas turbines (Regeneration, inter-cooling, and reheat cycles). Combined power cycle. Research by topics. ***Pre-req.: MCHE 321.***

MCHE 332 FLUID MECHANICS II (3Crs.: 3Lec, 0Lab): Dimension analysis using PI-Theorem. Fluid flow kinematics for three- dimensional fluid motions, velocity potential, Basic and combined flow field applications, Continuity equation. Lift and Drag forces. Navier-Stokes equations, Applications on Navier-Stokes equations. ***Pre-req.: MCHE 331.***

MCHE 514 PROGRAMMABLE LOGIC CONTROLLERS (3Crs.: 3Lec, 0Lab): PLC operation. PLC memory; Ladder logic; structured logic, flowchart-based, and state-based design; instruction list and structured text programming; Interface of sensors, actuators, and I/O devices; selecting PLC; development of PLC-based systems; lab experiments. Projects. ***Pre-req.: MCHE 315.***

MCHE 523 THERMAL EQUIPMENT DESIGN (3Crs.: 3Lec, 0Lab): Introduction to heat exchangers. LMTD method. ε-NTU method. Heat transfer and pressure drop correlations. Double-pipe heat exchangers.

Shell-and-tube heat exchangers. Compact heat exchanger design (dry cooler, cooling and dehumidifying coil, indirect evaporative cooler). Direct contact heat exchangers. Computer applications. ***Pre-req.: MCHE 421.***

MCHE 529 THERMAL POWER STATIONS (3Crs.: 3Lec, 0Lab): Introduction to thermal power station. Types of thermal power station. Demonstration of simple Rankine cycle, impact of key parameters variation on cycle performance, review of modified Rankine cycles (reheat cycle, regenerative cycle, and co-generation cycle). Thermal analysis and design of the various components of the steam power plants (steam generator – steam condenser – cooling tower – feed water heaters) are given in details. Gas-turbine cycle and combined cycle. Concentrating solar collector analysis and design. ***Pre-req.: MCHE 421.***

MCHE 531 PUMP TECHNOLOGY (3Crs.: 3Lec, 0Lab): Introduction to pumps. Pump classifications. Centrifugal pump construction. Pump performance curves, operating points, discharge regulation, similarity law, speed variation, velocity triangle and cavitation. Pumps in series and parallel. Multi-stage pumps, axial flow pumps. Viscosity density and temperature effect on the pump performance. Specific speed. Effect of air entraining vortex from pump suction side. Priming of pumps. Axial, radial and mixed flow pumps design. Forces acting on different rotating elements, gland packing seals and mechanical seals. Pump system design project. ***Pre-req.: MCHE 332.***

MCHE 535 HYDRAULIC CIRCUITS (3Crs.: 2Lec, 2Lab): Design of basic hydraulic circuits, elements of hydraulic circuits and design factors, Positive displacement oil pumps as sources of hydraulic power, oil reservoirs, pipes, control valves: pressure, direction and flow control, fluid power actuators: hydraulic cylinders, hydraulic motors, standard symbols according to ANSI Standard and graphical representation, basic hydraulic circuits and applications in practice. ***Pre-req.: MCHE 331.***

MCHE 540 FLUID THERMAL SYSTEM DESIGN (3Crs.: 3Lec, 0Lab): Specifications of fans, compressors, and blowers. Design, operation and fans selection for ventilation systems. Fire pumps specifications and safety codes based on NFPA 20. Fire Standpipes system design and calculation based on NFPA 14. Mechanical specification codes and standards used in the mechanical services in building. Pump stations design. Pipe network systems. Water hammer protection causes effect & solution. High-rise building water distribution riser diagram, fixture load calculation, hot and cold pipe sizing. Booster pump estimates and selections for hot and cold-water systems. Course Projects in the implementing of fluid thermal systems design and plumbing. ***Pre-req.: MCHE 531.***

MCHE 562 SENSORS AND ACTUATORS (3Crs.: 3Lec, 0Lab): Introduction to contemporary sensor and actuator technologies. Smart sensor and actuator materials (piezoelectric, shape memory alloys, electro-rheological, etc.). Application Specific Integrated Circuits (ASIC). Smart sensors and sensor fusion. Project. ***Pre-req.: MCHE 315.***

MCHE 564 AUTOMOTIVE ENGINEERING (3Crs.: 3Lec, 0Lab): Engine parts and construction. Engine classifications. Estimation of engine power, fuel consumption and efficiencies. Engine combustion and emissions. Carburetor and electronic fuel injection systems. Mechanical and electronic ignition systems. Engine cooling and lubrication systems. Automotive disc and drum brakes. Power brakes. Anti-lock brake system (ABS). Automotive manual and power steering systems. Conventional, air, and active suspension systems. Four wheel steering. Components of power train including Clutches, transmission, and differential.

MCHE 565 TECHNOLOGY VENTURES (3Crs.: 3Lec, 0Lab): This course teaches students how to articulate a well-reasoned, easily understood business plan, understand the product realization process, set and achieve targets, prepare budgets, find capital by effectively communicating the idea to those who can finance it, hire the right mix of marketing and technical talent, know the market by engaging in real time market research, and focus on the customer; team project. ***Pre-req.:INME 221.***

MCHE 566 AUTOMOTIVE CONTROL (3Crs.: 3Lec, 0Lab): Concepts of automotive control, Electro-mechanical systems that are controlled by electronic control modules via an appropriate algorithm such as fuel injection timing control, emission control, transmission clutch control, anti-lock brake control, traction control, stability control, etc. ***Pre-req.: MCHE 564.***

MCHE 571 REFRIGERATION AND HVAC APPLICATIONS (3Crs.: 2Lec, 2Lab): Application of space heating load calculation and shop drawing project utilizing AutoCAD or Revit to draw the water

heating system used in residential, commercial, and healthcare settings. The design incorporates pipe sizing as well as boiler, pump, and radiator selection. Duct design, grille selection and shop drawing for parking lot ventilation, including smoke management techniques and requirements based on ASHRAE and NFPA (stair, lift and atrium pressurization). Design calculation and shop design for a variable air volume ducted system with equipment selection. Chiller piping system design applications (constant primary, constant primary-variable secondary, and variable primary pumps). Metering device selection, evaporator selection and design, condenser selection and design. Course Projects. ***Pre-req.: MCHE 422.***

MCHE 572 WATER DESALINATION TECHNOLOGIES (3Crs.: 3Lec, 0Lab): The course provides theoretical and practical aspects of seawater/brackish water desalination technologies. The main topics include basic concepts of water chemistry; detailed evaluation and technology description of thermal-based (SSE, MEV, MSF, MED, and VC) and membrane-based (RO) desalination processes; conventional and innovative intake and pre-treatment systems; process design and system performance; fouling, scaling (including bio-fouling) and cleaning; product water quality and post-treatment. Other related topics such as innovative desalination technologies (Forward Osmosis (FO), Membrane Distillation (MD), Absorption/adsorption Desalination; energy consumption; environmental impact; economics; hybrid systems; desalination using renewable energy; trends of desalination market; full scale plants and case studies, will also be covered in this course depending on time availability. ***Pre-req.: MCHE 421.***

MCHE 573 OPERATION AND MANAGEMENT OF THERMAL POWER STATIONS (3Crs.: 3Lec, 0Lab): Various systems and cycles used in producing electrical power. Boiler operation and control, boiler testing and maintenance, water treatment procedure, condenser operation and troubleshooting, steam turbine construction, steam turbine governing systems types and operation, gas turbine operation and control, variable load management and power plants economics and power distribution systems. ***Pre-req.: MCHE 529 or MCHE 521.***

MCHE 575 REVIT MEP FOR MECHANICAL ENGINEERS (3Crs.:0Lec, 6 Lab): The aim of this course is to effectively communicate building information using Autodesk Revit software for mechanical and plumbing systems of building structures. Principles and applications of MEP modeling and documentation. Revit project setup for engineering purposes. Work sharing concepts, methods, tools and commands with Revit for building design, construction documentation and presentation purposes. Topics include working with interrelated architectural files where students learn how to add mechanical equipment to a Mechanical Services project, create HVAC zones, add insulation, piping systems, fire protection systems and more**. *Pre-req.: MCHE 422*.**

MCHE 581 COMPUTATIONAL FLUID DYNAMICS (3Crs.: 3Lec, 0Lab): Introduction to the methods and analysis techniques used in computational solutions of fluid mechanics and heat transfer problems; finite difference method; partial differential equations; discretization approaches; stability, consistency, and convergence; finite-volume formulations; explicit and implicit methods; code and solution verification; incompressible flows; validation and uncertainty quantification; simulation and design using commercial CFD code. ***Pre-req.: MCHE 421 and MCHE 332.***

D. Final Year Project

RNEE 501 FINAL YEAR PROJECT I (1Cr) / RNEE 502 FINAL YEAR PROJECT II (3Crs): After completing 109 credits of course work, the student becomes eligible to sign up for the Final Year Project (FYP) that extends over two semesters. The FYP experience requires students to work in teams to complete a specific project, submit a technical report, and give a presentation on a significant, relevant, and comprehensive engineering problem. The FYP is intended to stimulate student innovation and critical thinking, and build skills in formulating, designing, developing, building, communicating, and managing engineering projects. The project aims to provide students with a transitional experience from the academic world to the professional world. ***Pre-req. for RNEE 501: ENGR 500 or MCHE 500 / Pre-req. for RNEE 502: RNEE 501.***

E. Internship

RNEE 499 INTERNSHIP (1Cr): professional training which should not be less than four weeks. The training is followed by a presentation session where the students are supposed to present what they have learned.

Study Plan
Bachelor of Engineering in Renewable Energy Engineering (150 Credits)

First Semester (18 credit hours)		**Crs.**	**Pre/Co-requisites**
CHEM 241	Principles of Chemistry	3	
MATH 281	Linear Algebra	3	
MCHE 213	Dynamics	3	
BLAW 001	Human Rights	1	
MCHE 201	Engineering Drawing and Graphics	3	
PHYS 280	Classical Physics	3	
ENGL 001	General English	2	

Second Semester (15 credit hours)		**Crs.**	**Pre/Co-requisites**
COMP 208	Programming I	3	
MATH 282	Calculus	3	
CVLE 210	Statics	3	
PHYS 281	Electricity and Magnetism	3	
INME 221	Engineering Economy	3	

Summer 1 (8 credit hours)		**Crs.**	**Pre/Co-requisites**
ARAB 001	Arabic Language	2	
ENGL 211	Advanced Writing	2	Pre: ENGL 001
	General Electives[1]	4	

Third Semester (17 credit hours)		**Crs.**	**Pre/Co-requisites**
MCHE 321	Thermodynamics I	3	Pre: PHYS 280 or PHYS 282
MCHE 331	Fluid Mechanics I	3	Pre: PHYS 280 or PHYS 282
MCHE 341	Mechanics of Materials for RNEE	3	Pre: CVLE 210
RNEE 201	Fundamentals of Renewable Energy	2	
POWE 211	Electric Circuits (for Mechanical Engineering students)	3	Pre: PHYS 281
MATH 380	Discrete Mathematics	3	Pre: MATH 282

Fourth Semester (18 credit hours)		**Crs.**	**Pre/Co-requisites**
MATH 283	Differential Equations	3	Pre: MATH 281 and MATH 282
MATH 381	Probability and Statistics	3	Pre: MATH 282
MCHE 342	Mechanical Design for RNEE	3	Pre: MCHE 201 and MCHE 341
RNEE 322	Green Buildings and LEED	3	Pre: RNEE 201
POWE 282	Power Electronics	2	Pre: POWE 211
POWE 282L	Power Electronics and Solid State Drives Lab	1	Pre or Co: POWE 282
CHEM 247	Electrochemistry	2	Pre: CHEM 241
CHEM 247L	Electrochemistry Lab	1	Pre or Co: CHEM 247

Summer 2 (5 credit hours)		Crs.	Pre/Co-requisites
MATH 284	Numerical Analysis	3	Pre: MATH 283
ENGL 300	Speech Communications	2	Pre: ENGL 001

Fifth Semester (15 credit hours)		Crs.	Pre/Co-requisites
MCHE 421	Heat Transfer	3	Pre: MATH 284 and MCHE 321
MCHE 315	Instrumentation and Measurement	2	Pre: MATH 381 and (MCHE 214 or POWE 282)
MCHE 315L	Instrumentation and Measurement Lab	1	Pre or Co: MCHE 315
RNEE 431	Wind Energy	3	Pre: MCHE 331
POWE 381	Electromechanical Conversion Systems	3	Pre: POWE 211
ENGR 500	Research Methodology	2	Pre: ENGL 211
ENGR 001	Engineering Ethics	1	

Sixth Semester (18 credit hours)		Crs.	Pre/Co-requisites
MCHE 422	Refrigeration and Air Conditioning	3	Pre: MCHE 421
MCHE 418	Dynamic Systems	3	Pre: MATH 283
MCHE 533	Hydraulic Machinery and Stations	3	Pre: MCHE 331
POWE 382	Power System Operation, Protection, and Analysis	3	Pre: POWE 381
POWE 482	Photovoltaic Systems	3	Pre: POWE 282
	Technical Elective[2]	3	

Summer 3 (1 credit hour)		Crs.	Pre/Co-requisites
RNEE 499	Internship	1	

Seventh Semester (17 credit hours)		Crs.	Pre/Co-requisites
MCHE 526	Energy Management	3	Pre: MCHE 321
MCHE 515	Control Systems	2	Pre: MCHE 418
MCHE 515L	Control Systems Lab	1	Pre or Co: MCHE 515
RNEE 521	Building Energy Modeling	3	Pre: RNEE 322 and MCHE 422
RNEE 525L	Renewable Energy Lab	2	Pre or Co: RNEE 521
POWE 385	Modern Drives	2	Pre: POWE 381
RNEE 501	Final Year Project I	1	Pre: ENGR 500 or MCHE500
	Technical Elective[2]	3	

Eighth Semester (18 credit hours)		Crs.	Pre/Co-requisites
RNEE 526	Solar Thermal Energy Systems	3	Pre: MCHE 421
POWE 481	Grid Integration	3	Pre: POWE 382
RNEE 502	Final Year Project II	3	Pre: RNEE 501
WRNL 200	Work Ready Now	3	
	Technical Electives[2]	6	

[1] selected from the list of university elective courses.

[2] selected from the list of Renewable Energy Engineering elective courses.