Curriculum of BS in Renewable Energy

Effective for the Academic Session 2017 onward

Syllabus for B.S—Renewable Energy Session 2017 Onward Approved by Board of Studies held on June 7, 2017
Programme: BS in Renewable Energy  
Duration: 4 years  
Number of semesters: 8  
Number of weeks per semester: 16-18 (2 weeks for examinations)  
Total number of credit hours: 134  
Number of credit hours per semester: 17 (only in 8th semester 15 credit hours)  

**Note:** A comprehensive exam will be taken from taught courses before submission of final project report.

### Scheme of Studies

#### First Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title of the Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE-411</td>
<td>Introduction to Renewable Energy</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>RE-412</td>
<td>Metallurgy &amp; Workshop Practices</td>
<td>3(2-1)</td>
</tr>
<tr>
<td>RE-413</td>
<td>Fluid Mechanics</td>
<td>3(2-1)</td>
</tr>
<tr>
<td>PHY-414</td>
<td>Applied Physics-1</td>
<td>3(2-1)</td>
</tr>
<tr>
<td>MATH-415</td>
<td>Mathematics-I (Calculus)</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>IS-416</td>
<td>Islamic Studies or Ethics (for Non-Muslim students)</td>
<td>2(2-0)</td>
</tr>
<tr>
<td></td>
<td><strong>Total Credit hours</strong></td>
<td><strong>17</strong></td>
</tr>
</tbody>
</table>

#### Second Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title of the Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE-421</td>
<td>Thermodynamics</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>RE-422</td>
<td>Applied Mechanics</td>
<td>3(2-1)</td>
</tr>
<tr>
<td>RE-423</td>
<td>3D Modeling and Simulation</td>
<td>3(1-2)</td>
</tr>
<tr>
<td>CHEM-424</td>
<td>Applied Chemistry</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>MATH-425</td>
<td>Mathematics-II (Ordinary Differential Equations)</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>ENG-426</td>
<td>English Composition and Comprehension</td>
<td>2(2-0)</td>
</tr>
<tr>
<td></td>
<td><strong>Total Credit hours</strong></td>
<td><strong>17(14-3)</strong></td>
</tr>
</tbody>
</table>

#### Third Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title of the Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE-431</td>
<td>Wind Energy</td>
<td>3(2-1)</td>
</tr>
<tr>
<td>RE-432</td>
<td>Heat and Mass transfer</td>
<td>3(2-1)</td>
</tr>
<tr>
<td>PHY-433</td>
<td>Applied Physics-II</td>
<td>3(2-1)</td>
</tr>
<tr>
<td>EE-434</td>
<td>Circuit Theory</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>MATH-435</td>
<td>Mathematics-III (Linear Algebra)</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>PST-436</td>
<td>Pakistan studies</td>
<td>2 (2-0)</td>
</tr>
<tr>
<td></td>
<td><strong>Total Credit hours</strong></td>
<td><strong>17</strong></td>
</tr>
</tbody>
</table>

#### Fourth Semester

<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE-441</td>
<td>Hydro Power Systems</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>RE-442</td>
<td>Basic Electronics</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>RE-443</td>
<td>Communication &amp; Presentation Skills</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>GEOL-444</td>
<td>Geological Perspective of Renewable Energy</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>MATH-445</td>
<td>Numerical Analysis</td>
<td>3(2-1)</td>
</tr>
<tr>
<td>STAT-446</td>
<td>Statistics and Probability</td>
<td>2(2-0)</td>
</tr>
<tr>
<td></td>
<td><strong>Total Credit hours</strong></td>
<td><strong>17</strong></td>
</tr>
</tbody>
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<tr>
<th>Course Code</th>
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<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE-451</td>
<td>Tidal and Geothermal Energy</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>RE-452</td>
<td>Energy Storage</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>RE-453</td>
<td>Solar Energy</td>
<td>3(2-1)</td>
</tr>
<tr>
<td>RE-454</td>
<td>Nanoscience and Energy</td>
<td>2(2-0)</td>
</tr>
<tr>
<td>RE-455</td>
<td>Mechatronics</td>
<td>3(2-1)</td>
</tr>
<tr>
<td>GEOG-456</td>
<td>Geographical Perspective of Renewable Energy in Pakistan</td>
<td>3(3-0)</td>
</tr>
</tbody>
</table>

**Total Credit hours**: 17

### Sixth Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title of the Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE-461</td>
<td>Microbial Bioenergy and Biofuel</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>RE-462</td>
<td>Hydrogen and Fuel Cells</td>
<td>3(3-1)</td>
</tr>
<tr>
<td>RE-463</td>
<td>Power Electronics</td>
<td>3(2-1)</td>
</tr>
<tr>
<td>RE-464</td>
<td>RS and GIS for Renewable Energy Resources</td>
<td>3(2-1)</td>
</tr>
<tr>
<td>RE-465</td>
<td>Photoactive Materials and Thermal Characterization</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>RE-466</td>
<td>Environmental Impact Assessment</td>
<td>2 (2-0)</td>
</tr>
</tbody>
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**Total Credit hours**: 17

### Seventh Semester

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<tr>
<th>Course Code</th>
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<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>RE-471</td>
<td>Photovoltaic</td>
<td>3(2-1)</td>
</tr>
<tr>
<td>RE-472</td>
<td>Nuclear Energy and Diverse Reactors</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>RE-473</td>
<td>Digital Electronics</td>
<td>3(2-1)</td>
</tr>
<tr>
<td>RE-474</td>
<td>Project Report- I</td>
<td>3(0-3)</td>
</tr>
<tr>
<td>RE-475</td>
<td>Professional Ethics</td>
<td>2(2-0)</td>
</tr>
<tr>
<td></td>
<td><strong>Elective Course-I (choose one from the following)</strong></td>
<td></td>
</tr>
<tr>
<td>RE-476</td>
<td>Thin Film Technology And Applications</td>
<td></td>
</tr>
<tr>
<td>RE-477</td>
<td>Solar Passive Architecture</td>
<td></td>
</tr>
<tr>
<td>RE-478</td>
<td>Heating Ventilation and Air Conditioning Systems</td>
<td></td>
</tr>
</tbody>
</table>

**Total Credit hours**: 17

### Eighth Semester

<table>
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<tr>
<th>Course Code</th>
<th>Title of the Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE-481</td>
<td>Boilers and Power Plant</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>RE-482</td>
<td>Power Generation</td>
<td>3(3-0)</td>
</tr>
<tr>
<td>RE-483</td>
<td>Project Report- II</td>
<td>3(0-3)</td>
</tr>
<tr>
<td>RE-484</td>
<td>Instrumentation and control</td>
<td>3(3-0)</td>
</tr>
<tr>
<td></td>
<td><strong>Elective Course-II (choose one from the following)</strong></td>
<td></td>
</tr>
<tr>
<td>RE-486</td>
<td>New Energy Technologies</td>
<td></td>
</tr>
<tr>
<td>RE-487</td>
<td>Energy Efficient buildings</td>
<td></td>
</tr>
<tr>
<td>RE-488</td>
<td>Fabrication of Solar Cells</td>
<td></td>
</tr>
</tbody>
</table>

**Total Credit hours**: 15
INTRODUCTION TO RENEWABLE ENERGY

OBJECTIVE
Students are introduced to different types of renewable energy resources by engaging in various activities to help them understand the transformation of energy (solar, water, nuclear, biomass and wind) into electricity. Students explore the different roles engineers who work in renewable energy fields have in creating a sustainable environment – an environment that contributes to greater health, happiness and safety.

CONTENT
Promising renewable energy sources, their potential availability and present status, existing technologies and availability, solar energy: Sun-Earth relationship, solar geometry, sun path and solar irradiance, solar spectrum. Solar constant, atmospheric effects, global distribution, effects of tilt angle, daily and seasonal variations, resource estimation. Extraterrestrial, global, direct, diffused radiation, Flat plate collectors, their designs, heat transfer, transmission through glass, absorption transmission of sun energy, selective surfaces, performance, and efficiency, Photovoltaic: PV effect, materials, solar cell working, efficiencies, different types of solar cells, characteristics, (dark, under illumination), efficiency limiting factors, power spectral response, fill factor, temperature effect; PV systems, components, modules, arrays, controllers, inverters, storage, PV system sizing, performance and applications, Wind: Global distribution, resource assessment, wind speed, height and topographic effects, power extraction for wind energy conversion, wind mills, their types, capacity, properties, wind mills for water lifting and power generation, environmental effect., Hydropower: Global resources, and their assessment, classification, micro, mini, small and large sources principles of energy conversion; turbines, their working and efficiency for micro to small power systems, environmental impact, Biogas: Biomass sources; residue, farms, forest. Solid wastes; agricultural, industrial and municipal wastes etc.; applications, traditional and nontraditional uses: utilization, process, gasification, digester, types, energy forming, Environment issues, Geothermal: Temperature variation in the earth, sites, potentials, availability, extraction techniques, applications; water and space heating, power generations, problems, environmental effects, nuclear: Global generations of reserves through reprocessing and breeder reactors, growth rate prospect of nuclear fusion, safety and hazards issue.

BOOKS RECOMMENDED
**OBJECTIVE**
To enable the students to analyze the properties and characteristics of metals and their treatments. The students will be provided the opportunities to learn and exercise various workshop practices to enhance their engineering skills.

**CONTENTS**
Safety and First Aid, Production and properties of common engineering materials: Ferrous metals, iron ores, properties and uses of pig iron, cast iron, wrought iron, steel, standard processes of manufacturing of Iron and steel, open hearth process, basic oxygen processes, production of ingots. Composition/ properties and uses of plastics, rubber, fibre glass and composite materials.


Heat treatment theory and process, heat treatment of steel, annealing, hardening, tempering, normalizing, surface hardening, quenching, heat treatment equipment.

Types of welding process, welding materials, inspection and testing of welded joints, Welding flames and materials, cutting of metals, gas welding processes. Foundry, casting, hand molding tools, foundry cores, properties of core and, crucibles, handling and care.

**PRACTICAL**
Identification of tools and machines in the workshop; Identification of different metals by spark tests and advance methods; Demonstration of different heat treatment processes; Practice of arc welding; Practice of gas welding; Safety and first aid in the workshop related to electrical, mechanical and other accidents. Safety in the use of hand tools; Visits to local foundries.

**BOOKS RECOMMENDED**
dimensions of flow, streamlines, path lines, flow patterns for different references, continuity equation, source flow, sink flow, flow nets, uses and limitations of flow net. General equations of steady flow, heads, Bernoulli’s equation and its practical applications, hydraulic and energy grade lines, power consideration in fluid flow, cavitation’s, head losses, solution of flow problems, impulse-momentum principle and application, force exerted on a stationary and moving bodies (flat and curved), relation between absolute and relative velocities, reaction of a jet, jet propulsion, torque in rotating machines, Orifices, weirs, notches and venturi meter, pitot tube, coefficient of contraction, velocity and discharge, derivation of their discharge formulae and their applications.

PRACTICALS
Demonstration of various parts of hydraulic bench; Experimental study of laminar and turbulent flow; Experimental study of tube gauges and dead weight pressure gauges; Calibration of orifices by various methods; Calibration of Venturimeter; Calibration of rectangular and triangular notch; Verification of Bernoulli’s theorem; Determination of metacentric height; Viscosity of a given fluid by viscometer; Drag on a small sphere.

BOOKS RECOMMENDED

PHY-414 Applied Physics-1 3(2-1)

OBJECTIVE
To study the basic concepts of electromagnetic theory.

CONTENTS
Electric potential: Electric Potential due to Point Charge and an Assembly of Point Charges: Electric Potential of Continuous Charge Distribution (Infinite Line Charge, Electric Field as Gradient of Electric Potential; Poisson and Laplace Equations, power, single phase and 3-phase A.C. supply. RLC Series and Parallel. Vector addition and subtraction of A.C. voltages, Electromagnetic Induction: Faraday’s Law of Electromagnetic induction; Lenz’s Law; Motional E.M.F.; Induced Electric Fields., A.C/D.C. motors: Concept of rotating fields, polyphase induction motor, lap and wave winding of single phase and three phase motors, measuring instruments, transformers. A.C power generators. Electrical distribution, Electric controls, motor controls, and protection, Capacitors and Dielectrics: Capacitance; Calculation of Electric Field inside a Capacitor; Calculation of Capacitance of Parallel Plate, Spherical and Cylindrical Capacitors; Storage of Electrical Energy in a Capacitor; Capacitor with a Dielectric; Energy Stored in the Presence of a Dielectric; Molecular View of a Dielectrics; Gauss’s Law for Dielectrics.

PRACTICALS
Construction of wiring systems, fuses, switches of various types insulators, Circuits design and drawing of a typical farm electrical system, Selection of motor for various farm equipment such as forage cutter, feed-grinders, and shop tools, Practice on repair and adjustment of electric motors, switches, fuses, transmission wiring controls, Study of 3 phase induction motor, Study of star and delta connections, Study of semiconductor, triode, diode valve and transistors, Use of AVO meter, CRO, plani meter, Fabrication of full wave
rectifier and inductance study of its wave-shape, Measurement of self-inductance and mutual inductance.

**BOOKS RECOMMENDED**

1. Theraja, B.L. A Text Book of Electrical Technology, S. Chand & Co. Ltd. New Delhi, India, Latest edition

**MATH-415 | Mathematics -I (Calculus) | 3(3-0)**

**OBJECTIVES**

Calculus serves as the foundation of advanced subjects in all areas of mathematics. This is the first course of Calculus. The objective of this course is to introduce the fundamental concepts of limit, continuity, differential and integral calculus of functions of one variable.

**CONTENT:**


**RECOMMENDED BOOKS:**

IS-416 | Islamic Studies or Ethics (for Non-Muslim students) | 2(2-0)

**OBJECTIVES**
To provide Basic information about Islamic Studies, Islamic Civilization, prayers and other worships and issues related to faith and religious life.

**CONTENTS**

**BOOKS RECOMMENDED**

1. Hameed ullah Muhammad. Emergence of Islam, IRI, Islamabad
2. Hameed ullah Muhammad. Muslim Conduct of State
3. Hameed ullah Muhammad. Introduction to Islam
4. Hussain Hamid Hassan. An Introduction to the Study of Islamic Law, leaf Publication Islamabad, Pakistan
5. Ahmad Hasan. Principles of Islamic Jurisprudence, Islamic Research
6. Institute, International Islamic University, Islamabad
9. Dr. Muhammad Zia-ul-Haq. Introduction to Al Sharia Al Islamia, Alama Iqbal Open University, Islamabad
OBJECTIVE
To educate the students about various thermodynamic cycles of heat engines and refrigeration systems.

CONTENTS
Heating and expansion of gases: Units of heat, gases and vapors, constant volume and constant pressure, P-V diagram, specific heat of gases, internal energy of gas, law of conservation of energy, methods of heating and expanding gases and vapors, work done by gas in expanding.
Laws of perfect gases: The two laws of thermodynamics, the heating of gases, equations for different types of heating methods. Air cycles: Cycles of operation, air standard efficiency of a cycle, reversible process, reversible cycles, reversibility and efficiency, Carnot cycle, Otto cycle, diesel cycle, mean effective pressure.
Entropy of gases: Entropy and heat, T-S diagrams, Carnot, Otto, diesel and dual combustion cycles on T-S diagrams.
Air compressors: functions, compressor types, reciprocating and rotary compressors, single and multistage compressors, cylinder clearance, work done, compressor efficiency.
Compound expansion: advantages of compound expansion, tandem type of two- cylinder compound engine, receiver type compound engine; combined indicator diagram for compound engine, Calculations for cylinder uni-flow engine.
Refrigeration: Co efficient of performance, units of refrigeration, air compression refrigeration, vapor compression refrigeration, refrigeration cycles, rating, quality of refrigerant and general considerations, components of refrigeration system, heat pumps.

PRACTICALS
Study of working principles of two stroke and four stroke engines using models; Demonstration of Joule's law; Study of rotary and reciprocating air compressors and their characteristic curves; Study of PV diagram of diesel/gasoline engines; Analysis of engine flue gases for CO, CO2, NO2, etc.; Determination of energy content of different fuels using calorimeter; Study of heat transfer using refrigeration and air conditioning cycle; Measurement of fuel viscosity using viscometer; Determination of flash point and fire point of different petroleum products.

BOOKS RECOMMENDED
OBJECTIVE
Teaching basic principles of force analyses in engineering systems.

CONTENTS
- Particle Dynamics: Newton’s Laws of Motion and their Applications; Frictional Forces; The Dynamics of Uniform’ Circular Motion; Equations of Motion for Constant and Variable Forces; Time Dependent Forces; Motion in a Resistive Medium; Projectile Motion with and without Air Resistance; Non-inertial Frames and Pseudo Forces; Cohesive Forces. Work, Power and Energy: Work done by a Constant and Variable Force (one and two dimensional cases); Work-Energy Theorem; Power; Conservative Forces; Potential Energy; Conservation of Energy in One, Two and Three Dimensional Systems; Quantization of Energy. System of Particles: Two-Particle Systems; Many-Particle Systems; Centre of Mass (C.M), Calculation of Centre of Mass using integral rules; calculation of C.M (Uniform rod, cylinder and Solid Sphere); Linear Momentum of a System of Particles and its Conservation; Systems of Variable Mass; Rocket Equation. Gravitation: The Law of Universal Gravitation; Gravity near Earth’s Surface; Gravitational Effect of a Spherical Mass Distribution; Gravitational Potential Energy; Calculation of Escape Velocity; Gravitational Field and Potential; Radial and Transverse Components of Velocity and acceleration: Motion of Planets and Kepler’s Laws (Derivation and Explanation); Motion of Satellites; Energy Considerations in Planetary and Satellite Motion; Qualitative Discussion on Application of Gravitational Law to the Galaxy.

PRACTICALS
To verify the law of polygon of forces, the law of parallelogram of forces, the principles of moments, the co-efficient of friction between surfaces. Special numerical problems and assignments; Moment of inertia of fly wheel mounted on wall and a wooden block by suspension.; Efficiency of various models of machines; Modulus of rigidity of metal bar by static and dynamic methods; Special numerical problems and assignments.

BOOKS RECOMMENDED
   Latest edition

PRACTICALS
Introduction to drawing instruments and their use, various scales, practice of orthographic projection missing lines in orthographic projection, Drawing three views of different objects, Practice of Dimensioning and Lettering, Practice of Sectioning, Conversion of orthographic projection into isometric view, Creating drawings of Engineering Fasteners like Rivets, Cotters Joints, threads etc. Drawing and working problems on AutoCAD

BOOKS RECOMMENDED

CHEM-424 Applied Chemistry 3(3-0)

OBJECTIVE
To study the basic concepts of chemistry including periodic table, hydrogen and hydrides, electrochemical cells, hydrocarbons, organic polymers, Chromatography and spectroscopy.

CONTENTS:

BOOKS RECOMMENDED

8. Sykes, F., Organic reaction Mechanism.

| MATH-425 | Mathematics -II (Differential Equations) | 3(3-0) |

OBJECTIVE

To introduce students to the formulation, classification of differential equations and existence and uniqueness of solutions. To provide skill in solving initial value and boundary value problems. To develop understanding and skill in solving first and second order linear homogeneous and non-homogeneous differential equations and solving differential equations using power series methods.

CONTENTS


BOOKS RECOMMENDED


<table>
<thead>
<tr>
<th>ENG-426</th>
<th>English Composition and Comprehension</th>
<th>2(2-0)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OBJECTIVE</strong> To improve English grammar and writing skills including essay writing, different types of applications, report writing and to improve student’s communication skills.</td>
<td></td>
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</tr>
<tr>
<td><strong>CONTENTS</strong> Composition: Adverb and Adjectives; their forms and use; Articles and their use, prepositions; Relative pronouns, clauses; Conditional sentences; Correction of sentences. Comprehension: Getting the essential information; Effective communication; Comprehension writing, rules, practice; Order of importance: Application for job; Technical Report writing; Essay writing; Critical Reading and Thinking: The Damned Human Race (Article); How to live to be 200 (Article)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BOOKS RECOMMENDED</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Advance Essays for All, Advance Publishers, Muslim Centre, Urdu Bazar, Lahore, Latest edition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Ahmad, A. To The Point (English Grammar &amp; composition for degree), To the point publishers, Yousaf Market, Ghazni Street, Urdu Bazar, Lahore, Latest edition</td>
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<tr>
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<th>Wind Energy</th>
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<tbody>
<tr>
<td><strong>OBJECTIVE</strong> To study about properties and statistical analysis of the wind, wind generators, wind energy conversions and economics of wind energy.</td>
<td></td>
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</tbody>
</table>
| **PRACTICALS** Demonstration of different parts of Wind Turbine, performance evaluation and Energy measurement of a wind turbine, determination of wind tip speed for different sized wind turbines, calculation of transformation of a wind turbine, visit of wind power plant for mechanical and electrical energy, Application of Bernoulli’s principle in the laboratory,
Demonstration of impulse and reaction turbines model, power calculation from hydel turbine. Visit to Hydel power plant.

**BOOKS RECOMMENDED**


<table>
<thead>
<tr>
<th>RE-432</th>
<th>Heat and Mass transfer</th>
<th>3(2-1)</th>
</tr>
</thead>
</table>

**OBJECTIVE**
To study different engineering techniques in heat transfer, heat transfer mechanism, analogy between heat and mass transfer.

**CONTENTS**
Heat Transfer: Thermodynamics and heat transfer, engineering techniques in heat transfer, different forms of energy, heat transfer mechanisms; Principles of convective, conductive and radioactive heat transfer, shell balances concerning heat transfer, heat transfer coefficient correlations, boiling and condensation, thermal design of heat exchangers, transient heat transfer. Equations of change for isothermal systems, macroscopic balances for isothermal systems, analytical, approximate solutions to equations of heat, transfer, momentum, energy transport, interphase momentum, heat transfer. Empirical model the evaluation of heat transfer coefficients, Mass Transfer: Introduction, analogy between heat and mass transfer, mass diffusion, boundary conditions, steady mass diffusion through a wall, transient mass diffusion, diffusion in moving medium, mass convection, simultaneous heat and mass transfer. Principles of diffusion, mass transfer in turbulent flow, mass transfer theories, general principles of stage wise and continuous contacting operations, applications to absorption and distillation.

**PRACTICALS**
Method of heat transfer; Measurement of heat transfer by different methods; Study of boiling and convection heat transfer; types of heat exchangers, thermal processing; Experiments related to heat transfer from food products.

**BOOKS RECOMMENDED**


<table>
<thead>
<tr>
<th>PHY-433</th>
<th>Applied Physics-II</th>
<th>3(2-1)</th>
</tr>
</thead>
</table>

**OBJECTIVE**
To study the properties of light, wave nature of matter and basic concepts of quantum mechanics.

**CONTENTS:**
Properties of Light: The Electromagnetic Spectrum; Nature of Visible Light; the Speed of Light in Matter, the Propagation of Light; Path and Phase Difference. Origin of Quantum

BOOKS RECOMMENDED


EE-434  |  Circuit Theory  |  3(3-0)

OBJECTIVE
To study the combinations of circuit different, related laws and rules, different techniques of circuit analysis, network theorems, charge storing devices and make the students familiar with circuit maker software.

CONTENTS
Resistance, temperature effect on resistance, thermistors, super conductors, types of resistors, varistor, strain gauge, resistor color code, ohms law, power, and energy, efficiency, home electricity billing system. Series and parallel circuits: series circuit, voltage sources in series, Kirchhoff’s voltage law, voltage divider rule, voltage sources and ground, voltage regulation and the internal, resistance of voltage sources, protoboards (breadboards), parallel circuit, Kirchhoff’s current law, current divider rule, voltage sources in parallel, open and short circuits, series and parallel combinations, potentiometer loading, Method of analysis: current sources, source conversions, current sources in parallel, current sources in series, branch-current analysis, mesh analysis (general approach), mesh analysis (format approach), nodal analysis (general approach), nodal analysis (format approach), bridge networks, y- delta and delta –y conversions, Superposition theorem, Thévenin’s theorem, Norton’s theorem, maximum power transfer theorem, Millman’s theorem, substitution theorem, reciprocity theorem, Capacitors: Capacitance, capacitor construction, internal structure and capacitance analysis, types of capacitors, temperature effects, capacitor labeling, transients in capacitive networks (the charging phase, discharging phase), instantaneous values, capacitors in series and in parallel, energy stored by a capacitor,
Inductors: Magnetic field, electromagnets and their applications, inductance, inductor construction, induced voltage, RL transients, reluctance, ohm’s law for magnetic circuits, magnetizing force, Ampère’s circuit law, RLC series and parallel circuits.

SOFTWARE
Analysis of circuits in all chapters using multisim or circuit maker software

BOOKS RECOMMENDED
1. Robert L. Boylestad. Introductory Circuit Analysis, 12th /e,

MATH-435 Mathematics -III (Linear Algebra) 3(3-0)

OBJECTIVE
Linear algebra is the study of vector spaces and linear transformations. The main objective of this course is to help students learn in rigorous manner, the tools and methods essential for studying the solution spaces of problems in mathematics, engineering, the natural sciences, and social sciences and develop mathematical skills needed to apply these to the problems arising within their field of study; and to various real world problems.

CONTENTS

BOOKS RECOMMENDED

PST-436 Pakistan Studies 2(2-0)

OBJECTIVES
To provide basic information about Pakistan, historical background, struggles of the leaders and issues related to Pakistan development in earlier days.

CONTENTS
Historical Perspective: Two nation Theory; Ideology of Pakistan; Objectives for the creation of Pakistan; Important personalities in the creation of Pakistan; Sir Syed Ahmad Khan; Allama Iqbal; Quaid-e-Azam. Constitutional Development in Pakistan: Objectives Resolution and its constitutional importance; Ulma’s 22 points; Islamic provisions of 1956
constitutions; Islamic provisions of 1962; Constitution; Islamic provisions of 1973 constitution. Contemporary Pakistan: Objectives of Pakistan’s foreign policy; An overview of Pakistan’s foreign Policy; Pakistan’s foreign policy towards her neighboring countries; Regional organizations.

**BOOKS RECOMMENDED**


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<th>RE-441</th>
<th>Hydro Power Systems</th>
<th>3(3-0)</th>
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**OBJECTIVE**

To introduce the students with hydropower system,

**CONTENTS**

Introduction to hydropower system, Hydro power plant, Selection of Site, Classification of hydropower plants, classification of the typologies of hydropower systems and main components. Classification based on the size of the system, Reversible hydropower plant, Classification layout governing of turbines, Hydrologic (water) cycle, global hydro power, and hydro resource assessment, The Operating principles and the characteristics of selected turbines, Criteria for selection of a particular turbine, Concepts of gross head, net head, energy line, hydraulic grade line and available head, Conversion of hydro- power to electrical power: Shaft torque and shaft power. Plant -Equipment and performance, Performance enhancement techniques, equipment, Energy storage: pumped storage facilities. Economic analysis and environmental considerations,

**PRACTICALS**

Demonstration of impulse and reaction turbines model, power calculation from hydel turbine, Visit to Hydro power plant.

**BOOKS RECOMMENDED**

5. DC, Latest edition
OBJECTIVE
To study various types of semiconductor materials and diodes and their applications, transistors and its applications, FETs and their applications.

CONTENTS
Diodes and their applications: Semiconductors, Conductors and Insulators; N-Type Semiconductors; The PN-Junction and it’s Biasing; Current-Voltage Characteristic of a PN-Junctions; The Diode and its Models. Half-wave Rectifier; Full-wave Rectifier (Simple and Bridge); Smoothing Circuits, Zener Diodes; Optical Diodes (LED and Photodiode); LED Applications; Bipolar junction transistor: Basic Transistor Operation; Transistor Characteristics and Parameters (Alpha and Beta Parameters, Current and Voltage Analysis, Characteristic Curves, DC Load Line, Variation of Beta with Temperature); Transistor as an Amplifier: Transistor as a Switch; Photo transistor, The DC Operating Point; Voltage Divider Bias; Base Bias; Emitter Bias, Emitter feedback bias, Collector Feedback Bias, Bipolar junction transistor amplifiers: Amplifier Operation; Transistor AC Equivalent Circuits (r-Parameters, h – parameters); Common Emitter Amplifier DC and AC Analysis, (Voltage Gain, Current Gain, Power Gain); Common Collector Amplifier (Voltage Gain; Input Resistance; Current Gain; Power Gain); Darlington Pair; Common Base Amplifier (Voltage Gain, Input Resistance, Current Gain, Power Gain); Field effect transistors: Junction FET; MOSFET; Operation and Construction; Biasing (Self Bias and Voltage Divider Bias); IGBT, Common Source and Common Drain Amplifiers (DC and AC Analysis, Input Resistance, Voltage and Current Gain, Frequency Response etc), Common Gate Amplifier, Class-D Amplifier, Multistage Amplifier (RC Coupled); Tuned RF Voltage Amplifiers.

RECOMMENDED BOOKS.
2. A.P. Malvino. Electronic Principles 7/e with CD-Rom, Glencoe/ McGraw-Hill,

OBJECTIVE
To improve students’ communication and presentation skills

CONTENTS
Definition, types and functions of communication; effective communication and its barriers; verbal communication skills; speaking, speech making, listening, reading and writing. Preparing and delivering a speech, development of effective reading skills, art of effective writing, writing scientific and popular articles. Listening: the process, types, barriers and strategies for effective listening; non-verbal communications; characteristics, functions and types; leadership; concept, techniques, functions and characteristics; development of effective leadership skills.

PRACTICAL:
Communication & Presentation Skills labs related to speaking, speech making, listening, reading and writing.

BOOKS RECOMMENDED
This course aims to acquaint students with basic concepts in geology. The course will enable the students to understand the materials which makeup the Earth and the processes, which are constantly changing the face of the earth. The topics should be taught in context of renewable energy resources.

CONTENTS
Introduction and scope of geology, relationship with other sciences, geology and energy; origin of Solar System and the Earth; age of the Earth; internal composition and structure of the Earth; Continental Drift theory; the theory of Plate Tectonics, sea-floor spreading, mid oceanic ridges, subduction; isostasy; volcanism; geothermal gradient; introduction to rock forming minerals; Rock Cycle; classification and identification of common igneous, sedimentary and metamorphic rocks; hydrologic cycle; mechanical and chemical weathering; Geological work of running water, wind, lakes and oceans; principle of uniformitarianism; Law of superposition; Geological Time Scale; Geological dating: relative and absolute dating.

BOOKS RECOMMENDED

OBJECTIVE
To study the basic concepts of statistics and probability. Students will be able to understand different types of distributions, applications of Venn diagram, permutations and combinations.

CONTENTS
to engineering, Conditional probability, The multiplication law, Independent events, Baye’s formula, Permutations and combinations, Multiplication principle, Problems related to engineering, science and management, Applications of counting, Bernoulli trials, Binomial probability, Markov chains, Probability distribution, Expected value, Decision making, Problems related to engineering and management.

**PRACTICALS:**
Simple, Multiple and Component bar diagram, Histogram, Frequency polygon, Frequency curve, c.f. curve, cumulative percentage curve and locate Quantiles, Problem assignments relating probability, Fitting a Binomial distribution, Fitting a Poisson distribution, Fitting a Normal distribution, Sampling distribution of difference between two means, Application/use of t-test for Null hypothesis, Test of significance of association of attributes by x2-test (chi-square test), Testing goodness of fit, Calculating a simple, partial and a multiple correlation and their tests of significance, Fitting a simple linear regression equation and its test of significance by Analysis of Variance (F-test) and t-test, Analysis of variance of data from C.R.D., R.C.B.D. and L.S. design.

**BOOKS RECOMMENDED**

| MATH-446 | Numerical Analysis | 3(2-1) |

**OBJECTIVE**
To train the students in solving engineering problem and numerical, this course is designed to teach the students about numerical methods and their theoretical bases. The course aims at inculcating in the students the skill to apply various techniques in numerical analysis, understand and do calculations about errors that can occur in numerical methods and to use the basics of matrix analysis.

**CONTENTS**
Interpolation: Finite difference, Forward, backward and central difference and its operators form, Interpolation; Linear and higher order interpolating polynomials, Newton’s Gregory forward and backward difference interpolation formulas and its utilization, Lagrange interpolation and extrapolation, Numerical differentiation: Numerical differentiation based on differences, Numerical integration: Trapezoidal and Simpson’ approximations, Trapezoidal and Simpson’s by integration process, Numerical Solution of non-linear equations: Bracketing and iteration methods and its applications as multiple root methods, Direct solution of the system of linear equations; Gauss-elimination, Direct and indirect factorization, symmetric factorization, tridiagonal factorization, Iterative methods like Jacob’s iteration and Gauss-Seidel iteration, Numerical solution of initial value problems: Single-Step methods like Euler’s method, Euler’s modified method, Runge-Kutta method and its comparison with Taylor’s series expansion,

**PRACTICALS**
Numerical solution techniques will be elaborated and demonstrated

**BOOKS RECOMMENDED**

RE-451  Tidal and Geothermal Energy  3(3-0)

OBJECTIVE
To study the tidal and geothermal energy, tidal and wave energy conversion. A case study related to geothermal energy is also included.

CONTENTS

PRACTICALS
Laboratory demonstration of Heat source systems; demonstration of Well drilling techniques; case study for exploring geothermal resources; Demonstration of tidal and wave behave using computer applications; visits of Geothermal plants, visit of Tidal and wave regions.

BOOKS RECOMMENDED

RE-452  Energy Storage  3(3-0)

OBJECTIVE
To study about different energy storage systems including different types capacitors, batteries, advance batteries and to study some areas of applications of energy storage.

CONTENTS

BOOKS RECOMMENDED


OBJECTIVE
To learn the fundamentals of solar energy conversion systems, available solar energy and the local and national needs, solar engineering applications, emerging technologies; Understand the interdisciplinary approach for designing stand-alone PV systems, predicting performance with different systems, Implementing design with cost analysis and to gain system engineering expertise related to photovoltaic energy conversion: generation, storage, and grid connection processes for residential and industrial applications, and Learn how to advance the current technology of the solar energy systems for making the process economical, environmentally safe and sustainable. Students will be able to serve industries or academia involved in sustainable energy engineering.

CONTENTS
Solar energy: Solar insulation vs. world energy demand, current energy consumption from different sources, environmental and health effects. Sustainable Energy: Production and storage, resources and utilization. Fundamentals of solar cells: Types of solar cells, semiconducting materials, band gap theory, absorption of photons, excitons and photoemission of electrons, band engineering. Solar cell properties and design: p-n junction photodiodes, depletion region, electrostatic field across the depletion layer, electron and holes transports, device physics, charge carrier generation, recombination and other losses, I-V characteristics, output power; Single junction and triple-junction solar panels, metal-semiconductor hetero junctions, and semiconducting materials for solar cells. Low, medium
and high temperature collectors, types of solar energy collectors; Heat storage, storage media, steam accumulator, other storage systems, heat exchangers and applications of stored energy. Thermoelectricity, Peltier effect, Seebeck effect; Thermoelectric materials, Bismuth telluride, automotive thermoelectric generators, radioisotope thermoelectric generator; Thermoelectric power generators, thermoelectric refrigerators and heat pumps.

**PRACTICALS**

Identification of different types of solar cells, Exercises to draw I-V characteristic curves, Demonstration and evaluation of PV system, Performance evaluation of solar PV pumping system for irrigation applications, Demonstration of PV cell manufacturing processes and visit to different solar research organizations, Data acquisition using on-grid and off-grid PV system.

**BOOKS RECOMMENDED**

1. Green, M.A. Solar Cells: Operating Principles, Technology and system Applications, Kensington, N.S.W. University of New South Wales, Latest edition

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**RE-454 Nanoscience and Energy (2(2-0))**

**OBJECTIVE**

Nanoscience and Nanotechnology are at the forefront of modern research. In this course, students will learn the basics of physics, biology, and chemistry on the nanometer scale, supplemented by courses on technology and engineering to promote an understanding of practical applications. Students will also study characteristics of different Nano materials.

**CONTENTS**

Introduction to Nano Technology, Characteristics of Nano material, Nano particles, Bucky balls, CNTs and quantum dots, super capacitors, lithium ions battery, Hydrogen storage, Nano catalyst for optimized fuel production, Dye sensitized solar cell, quantum dot solar cell, semi-conducting Nano-materials and photo catalyst, metal oxides and sulfides for hydrogen production, limitation of existing photo catalyst, Introduction conducting polymers, organic light emitting diodes, conducting polymers solar cells.

**BOOKS RECOMMENDED**


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**RE-455 Mechatronics (3(2-1))**

**OBJECTIVE**

To understand the magnetic field and the reluctance of magnetic materials and air. Voltage-current characteristics and voltage regulation of generator. Torque speed characteristics and speed regulation motors. Various techniques for starting, speed control, reversing and
braking. Remedial measures of main problems occurring in DC machines. Generalized concept of electromechanical energy conversion.

**CONTENTS**


**BOOKS RECOMMENDED**


| GEOG-456 | Geographical Perspective of Renewable Energy | 3(3-0) |

**OBJECTIVE**

The course will provide geographical, conceptual and fundamental scientific frame-work for the students and will let them inculcate to understand the nature, geographical accessibility and spatial distribution pertaining to RE. The students will also understand the associated complications and problems of RE in different parts of Pakistan. It will highlight that there is no way other than to adopt RE for sustainable development and less environmental degradation, therefore, the students will get the concept that the use of RE got robust environmental benefits. The students will get a vision about the advantage, limitation and energy policy in Pakistan.

**CONTENTS**

The distribution of sources of renewable energy in diversified topography and climate of Pakistan; Significance of renewable energy in the national scenario where rural way of life is changing into urban way of life; Socio-economic development and demand of renewable energy; Spatial development of renewable energy and regional energy independence; RE and international politics.

The running water as a source of energy; The Indus water system and associated problems; the geothermal energy; The sea coast and its significance; the tides, sea waves, and their nature and mechanism, the potential of tides as source of energy; sea weeds and biomasses;
Wind energy its nature and potential in Pakistan; Introduction to solar irradiance and possible sunshine duration, its geographical distribution with respect to the location of Pakistan; The impact of latitude on solar radiation; The impact of landforms on solar irradiance; The north south extension of Pakistan and solar energy; The challenge of transition from conventional to renewable energy.

BOOKS RECOMMENDED

RE-461 Microbial Bioenergy and Biofuel 3(3-0)

OBJECTIVE
After completing the course, the students will be able to Familiarize with different types of microbes associated with bioenergy, Understand role of microbes in producing Bioenergy and Biofuel, Lab. scale production of bioenergy and biofuel using conventional digester.

CONTENTS
Types of biomass (e.g. wood waste, forestry residues, agricultural residues, organic municipal solid waste). Types of microbial fuels (Biodiesel, Bioethanol, Biomethane/Biogas, Biohydrogen etc.), Phenomena for production of Biofuel (bioenergy and biofuel etc.), role of microbes (aerobic and anaerobic) in biofuel production and isolation and characterization of different aerobic and anaerobic. Isolation and characterization of biofuel producing bacteria (bioenergy and biofuel etc.).

PRACTICALS
Standard operating Lab procedures (safety measures and microbiology lab), sterilization protocol for lab equipment and glasswares. Equipments used in isolation and characterization of biofuel producing bacteria, Different aerobic and anaerobic. Techniques helpful in isolating anaerobic biofuel forming Bacteria, Growth media, characterization with the help of morphology, biochemical tests, fluorescence test and other serological and molecular test, demonstration of laboratory scale conventional digester used in biofuel production. Visit to biofuel plant.

BOOKS RECOMMENDED
## RE-462 Hydrogen and Fuel Cells

**OBJECTIVE**
To study about the fuel-cell technology, introducing Hydrogen as a future energy carrier, students will be able to understand the usage of Hydrogen in internal combustion engines.

**CONTENTS**

**PRACTICALS**

**BOOKS RECOMMENDED**

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## RE-463 Power Electronics

**OBJECTIVE**
To provide adequate Knowledge and clear understanding about the construction, principle of operation, characteristics, protection, problems and applications of various Power electronic Semiconductor devices and their Control Circuits.

**CONTENTS**
Introduction: Recent advancement in Power Electronics and its Application, Power diodes, Freewheeling diodes Diodes with RC and RL LC and RLC loads. Types of Power transistors and their Characteristics. The thyristor: Principle of operation, characteristics, two transistor model of SCR, Thyristor types, Ratings, Protection and cooling, Thyristor Turn-on and Turn off, Commutation techniques, Series and Parallel operation of thyristors, Thyristor firing circuits. Static switches: Single phase and three phase A.C switches, Three

**PRACTICALS**
Practical/Simulation work is based on the above theoretical course

**BOOKS RECOMMENDED**

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**RE-464 | RS and GIS for Renewable Energy Resources | 3(2-1)**

**OBJECTIVE**
To relay essential concepts relating to geographical information systems such that candidates can use RS & GIS software independently, efficiently and meaningfully in support of resource assessment and site identification studies for renewable energy projects.

**CONTENTS**
Introduction: What is RS & GIS?, Example applications of RS & GIS, Coordinate systems and projections, Scale generalization and geo-referencing, Representing the real world using spatial data., Representing the real world using spatial data. II, Sources of spatial data, Terrain analysis and assessment, Spatial data analysis and prediction, Spatial statistics, MapInfo Workshops, Installation, MapInfo definitions, Open existing tables, Creating new tables, Drawing objects on a map, Raster coverage’s Universal translation of file formats, Spatial queries, Table menu functionality, Changing options and preferences, Creating and using layouts.

**PRACTICALS**
To determine coordinate systems and projections of different potential energy sites; To determine solar radiation from satellite imagery; To devise procedure of terrain analysis and its assessment; To identify the potential sites for setting of various renewable energy production units.

**BOOKS RECOMMENDED**

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**RE-465 | Photoactive Materials and Their Characterization | 3(3-0)**

**OBJECTIVES**
To train students about the use of different materials for the fabrication of photoactive materials in Nano scale which possess maximum ability to harvest the sun light in visible region. Furthermore the working and principles as well as the characterization of solar cells. In the practical domain the use of potentiostat and cyclic voltammetry is a prime importance.
CONTENTS

PRACTICALS
Photometric measurement, preparation of their films of photoactive materials, measurement of conductance, surface area demonstration, light intensity measurement.

BOOKS RECOMMENDED

OBJECTIVE
To understand the application of impact assessment techniques for various developmental activities.

CONTENTS

BOOKS RECOMMENDED

OBJECTIVE
To learn about solar photovoltaic system components, types, design and performance measurement.

CONTENTS
An introduction to Photovoltaics, the physics behind the technology, the devices and practical applications, Photovoltaic cells, Basic PV operation, PV technologies, 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, types and characteristics, Solar cells type, characteristics and configurations, solar charge controllers, types, characteristics, solar inverters type and characteristics’, Solar cables, solar mounting system, solar PV system types; Solar PV off grid, hybrid and on grid systems. Solar photovoltaic applications, solar system performance measurement and monitoring, solar system operation and maintenance.

PRACTICALS:
The practical work will be based on Theory Work.

BOOKS RECOMMENDED
5. Green, M.A. Solar Cells: Operating Principles, Technology and System Applications, University of New South wales, Latest edition

RE-472    Nuclear Energy and Diverse Reactors    3(3-0)

OBJECTIVE
To learn about the basic theory of nuclear physics including interaction of nuclear radiation with matter, nuclear reactors systems and components and nuclear safety risks.

CONTENTS

BOOKS RECOMMENDED
UNIVERSITY OF BALOCHISTAN QUETTA
Department of Renewable Energy

RE-473  Digital Electronics  3(2-1)

OBJECTIVE
To study different logic gates, theorems related to Boolean algebra, methods to simplify the complex Boolean functions, different types of codes their applications and conversions. The students will also be able to understand different combinational and sequential logic circuits.

CONTENTS
Boolean algebra and logical variables: Logic gates; Two Variable’s Theorems; De Morgan’s Theorems; applications of Boolean Algebra; Logical Function; SOP and POS; K-maps and their Uses; Don’t care Conditions; Different Binary Codes and their conversions (Gray code, Ex-3 Code, BCD Code, Weighted Code); Combinational logic circuits, Introduction to Logic Families: Half Adder; Full Adder; Half Subtractor; Full subtractor; Encoders (octal to Binary, Decimal to Binary and Hexadecimal to Binary); Decoders (Binary to decimal, Binary to Octal and Binary to Hexadecimal); code converters (Binary to Gray, Gray to Binary etc); Multiplexers; De-multiplexers. Sequential logic circuits: Basic Memory Elements; Flip-Flops (Set-reset Flip-Flop, D-type Flop, JK Flip-Flop and Master Slave Flip-Flop); Registers (Buffer Register, Shift Right Register, Shift Left register, Parallel in serial Out Register and Serial in Parallel Out Register); Counters (Asynchronous counter, Synchronous Counter, Up-down Synchronous Counter and Ring Counter).

PRACTICALS
To demonstrate the operation and characteristics of TTL Logic Gate and to show how. It can be used to perform any three basic logic functions, To demonstrate the operation and characteristics of CMOS Logic Gate and to show how it can be used to perform any three basic logic functions, To demonstrate the operation of XOR Logic Gate and XNOR Logic. To demonstrate the operation and characteristics of a set and rest (Latch) Flip Flop, To demonstrate the operation and characteristics of a D-type Flip Flop and storage register, To demonstrate the operation and characteristics of a binary counter, To demonstrate the operation of a BCD counter, To demonstrate the operation of Decoder gate, To demonstrate the operation of a BCD counter, To demonstrate the operation of Decoder, To demonstrate the operation and characteristics of bipolar integrated circuit shift register, To demonstrate the operation of Multiplexer.

BOOKS RECOMMENDED

RE-474  Project and Report-I  3(0-3)

A Project Report as a part of the course of studies for Bachelor’s Degree in Renewable Energy may be selected by the student and has to be accomplished in the last two semesters. At the end of 7th semester a student has to show the progress on the project while in the Last semester a complete project will be presented to the Departmental Semester committee and submitted the final report in written.

RE-475  Professional Ethics  2(2-0)

OBJECTIVE
The objective of the course is to improve the ethical standards of students in engineering.

CONTENTS

BOOKS RECOMMENDED

Elective Course – I (A)

| EC-476 | Thin Film Technology And Applications | 3(3-0) |

OBJECTIVE
To study about different techniques of deposition of thin films, study their characterization and applications

CONTENTS
Preparation of Thin-films: Kinetic aspects of Gases in a vacuum chamber, Classifications of vacuum ranges Production of vacuum, Pressure measurement in vacuum systems, Physical vapour deposition, Evaporation Techniques, Sputtering (RF & DC), Pulsed Laser deposition, Liquid Phase Epitaxy, Vapour Phase Epitaxy, Molecular Beam Epitaxy. Film growth and measurement of thickness Thermodynamics and Kinetics of thin film formation, Film growth, five stages, Incorporation of defects and impurities in films, Deposition parameters and grain size, structure of thin films, Microbalance technique, quartz crystal monitor photometric, Ellipsometry and interferometers, Measurement of rate of deposition using ratemeter, cleaning of substrate. Characterization: X-ray Diffraction(XRD), SEM, Photoluminescence(PL), Raman Spectroscopy, UV-Vis-IR Spectrophotometer, AFM, Hall effect, SIMS, X-ray Photoemission Spectroscopy (XPS), Vibrational Sample Magnetometers, Rutherford Back Scattering (RBS). Properties of thin films Dielectric properties, Experimental techniques for dielectric film, annealing effect, effect of film thickness on dielectric properties, determination of optical constants, Experimental techniques for determination of optical parameters, Magnetic and mechanical properties, Hall effect compilations, Adhesion, stress, strength, Raleigh surface waves, Ferromagnetic properties of Thin films, Experimental methods for measurement of mechanical properties of thin films. Applications Micro and optoelectronic devices, quantum dots, Data storage, corrosion and wear coatings, Polymer films, MEMS, optical applications, Applications in electronics, electric contacts, connections and resistors, capacitors and inductances, Applications of ferromagnetic and super conducting films, active electronic elements, microacoustic elements using surface waves, integrated circuits, thin films in optoelectronics and integrated optics.

BOOKS RECOMMENDED

Elective Course I (B)

| EC-477       | Solar Passive Architecture | 3(3-0) |

**OBJECTIVE**

To study different types of solar architectural and constructional techniques for designing different buildings and to promote building constructions with optimum use of solar energy

**CONTENTS**

Introduction to architecture; Architecture as the art of science of designing buildings; Building science and its significance; Energy management concept in building, Thermal Analysis and Design For Human Comfort, Thermal comfort; Criteria and various parameters; Psychometric chart; Thermal indices, climate and comfort zones; Concept of sol-air temperature and its significance; Calculation of instantaneous heat gain through building design of shading devices; Overhangs; Factors that effects energy use in buildings; Ventilation and its significance; Air-conditioning systems; Energy conservation techniques in air-conditioning systems, Passive Cooling And Heating Concepts, Passive heating concepts: Direct heat gain, indirect heat gain, isolated gain and sunspaces; Passive cooling concepts: Evaporative cooling, radiative cooling; Application of wind, water, and earth for cooling; Shading, paints and cavity walls for cooling; Roof radiation traps; Earth air-tunnel.

Heat Transmission In Buildings, Surface co-efficient: air cavity, internal and external surfaces, overall thermal transmittance, wall and windows; Heat transfer due to ventilation/infiltration, internal heat transfer; Solar, temperature; Decrement factor; Phase lag. Design of daylighting; Estimation of building loads: Steady state method, network method, numerical method, correlations; Computer packages for carrying out thermal design of buildings and predicting performance, Bioclimatic Classification, Passive concepts appropriate for the various climatic zones, Typical design of selected buildings in various climatic zones; Thumb rules for design of buildings and building codes. Energy Efficient Landscape Design Modification of microclimatic through landscape element for energy conservation; Energy conservation through site selection, planning, and design; Siting and orientation.

**BOOKS RECOMMENDED**


Elective Course I (C)

| EC-478       | Heating Ventilation and Air Conditioning Systems | 3(2-1) |

**OBJECTIVE**

To train the students about the design, development and parametric analysis of solar thermal cooling systems.

**CONTENTS**

Introduction, definition and basic terminology, refrigeration cycle, vapor compression cycle, COP, introduction to pressure-enthalpy chart, types of refrigerants, air cycle refrigeration, vapor absorption refrigeration and air conditioning, working principle of thermally driven cooling machines, single, double and triple effect absorption chiller, desiccant evaporative cooling, ejector cycle, indoor and outdoor air conditions, comfort air conditions and comfort zone, indoors air quality, psychrometry, psychometric chart and
psychometric properties, central air conditioning system, essential components of central air conditioning plant, water chiller and water heater, air handling unit, chilled water and hot water re-circulating system, return air supply system, fresh air supply system and air mixture chamber, supply fan, air dust cleaning and bacteria removal, air supply and air return terminals, diffusers, dampers, grills and registers, 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, air handling units for treatment of fresh and return, dust and bacteria removal methods, forced convection based air ventilator design, cooling towers, hydronic terminal units. Economics of solar cooling systems.

**PRACTICAL**
To find the co-efficient of performance of vapor compression cycle using general cycle refrigeration trainer; To determine the thermodynamics properties of air by using the psychometric chart; To represent refrigeration cycle on pressure enthalpy diagram; To calculate the degree of sub-cooled in condenser; To calculate degree of sub-cooled in liquid line; To calculate degree of super heat in the evaporator; To calculate the heat transfer rate; To determinate the rate of heat transfers from the air; To determinate the rate of heat transfers from the heater; To calculate the rate of heat absorbed in the evaporator at different cooling load; To demonstrate the operation and function of each component of heat pump; To understand the effect of cooling load to the super cooled; To understand the effect of cooling load to the sub cooled; To understand the effect of cooling load to compression ratio.

**BOOKS RECOMMENDED**

| RE-481 | Boilers and Power Plant | 3(3-0) |

**OBJECTIVE**
To produce skill about design, operations and maintenance of different types of boilers and steam turbines for power generation in industrial application

**CONTENTS**
Boiler Engineering: Introduction, types, construction, mounting, accessories steam cycle, steam nozzles, supersaturated expansion in nozzles, heat drop in saturated and supersaturated expansion, steam injector, steam turbine, work done, velocity diagram, work done in blading, velocity compounding, pressure compounding, impulse turbine, heat account for boiler and turbine, amount of fuel burnt, acceptance tests, analysis and calorific value of fuel, analysis of flue gases, amount of steam produced, pressure and quality of steam, design of boiler and pressure control system devices. Properties of steam, enthalpy of water, dryness fraction, enthalpy of wet steam, use of steam tables, super-heated steam, internal energy of steam. Power Plants: Steam Plants: Introduction, general layout of modern steam plants, steam generators, engines and auxiliary components, back pressure and pass out turbines, deviation of actual cycle from ideal, turbine pump and condenser. Gas Turbine and Power Plants: Introduction, the gas turbine cycle, modification in basic cycle, isentropic efficiency of compressors and turbines, inter cooling and reheating, explosion type gas turbine with solar heating, development and improvement in gas turbine. Jet propulsion plant, comparison of steam and gas power plants.
PRACTICALS
Demonstration and inspection of different types of boilers; Determination of calorific value of fuel; Analysis of flue gases using gas analyzer; Quality analysis of steam; Measurement of impulse force on vane of turbine; Assessment of power generation at output shaft; Visit to different power plants; Visit to sugar and textile industries to study boilers and steam power; Visit to nuclear and steam power plants.

BOOKS RECOMMENDED

RE-482 | Power Generation | 3(3-0)

OBJECTIVE
The students learn different power plant and modes of energy conversion to generate electrical energy in this course and the concepts of fuel cells are introduced.

CONTENTS
Thermal Power Plants: Sources of conventional energy and method of harnessing, special features and cycles used in steam, gas and diesel power plants, combine cycle systems and cogeneration. Location of the above plants and selection of units, prime movers and associated equipment, Hydroelectric Power Plants: The plants and their equipment, layouts, run of the river and accumulation type station, types of hydroelectric turbines and their stations, Nuclear Power Plants: Nuclear reaction, fission and fusion reaction, critical mass chain reaction, moderators, reactor control and cooling, classification of reactors, different types of reactors, radiation damages, shielding of gamma rays and neutrons, materials for construction, Thermoelectric Generators: Thermoelectric effect, solid state description of thermoelectric effect, analysis and design of thermoelectric generators, figure of merit, device configuration, solar and radioisotope powered generators, applications, MHD Generators: Gaseous conductors, analysis and design of MHD generator, problems associated with MHD generation, possible configuration, Photovoltaic Generators: Radiation principles, optical effects in semiconductors and PN junction, analysis and design of converter, fabrication of cells, solar cells in space, Fuel Cells: Thermodynamic principles, efficiency of fuel cell factors limiting the performance, design, new development in fuel cells, possibility of future use in electric vehicles. Wind power generation.

BOOKS RECOMMENDED

RE-483 | Project and Report-II | 3(0-3)
A Project and Report as a part of the course of studies for Bachelor’s Degree in Renewable Energy which is selected by the student in 7th semester has to be accomplished in the Final semesters. A complete project will be presented to the Departmental Semester Committee and submitted the final report in written.

RE-484 | Instrumentation and Control | 3(3-0)

OBJECTIVE
To train the students about the instrumentation techniques to monitor and control the operation of machines/equipment

**CONTENTS**
Terminology used in process measurements, range of sensors and transducers with reference to manufacturers’ terminology, construction and operation of modern sensors used to measure pressure, level, temperature and flow, typical applications for the sensors, signal conditioning and transmission, process control terminology, open and close loop control systems, Determine the medium required for successful transmission ‘name sensors, conditioners and display units for a range of specific purposes, tuning techniques, control actions required for different systems, main parts of a regulating unit, regulating unit with reference to standard terminology, including manufacturers’ specifications, Select the plug characteristics required for a specified process, characteristics of a range of regulating units, use of valve positioners, CV of a control valve from relevant data.

**PRACTICALS**
Measurement of Displacement by LVDT and Potentiometer; Measurement of wind velocity; Measurement of Force by Strain Gauges; Calibration of pressure gauges with dead weight tester; Measurement of Temperature by thermocouples; Computer interfacing for the depth and draft controls of tractors; Visit to Mechatronics labs of different institutions; Study of depth sensors.

**BOOKS RECOMMENDED**

**Elective Course II (A)**

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**PRE-REQUISITE:** Elective course-I: A (Thin film technology and applications)

**OBJECTIVE**
To study different developments in the field of superconductivity, parameters and types of superconductors. Some techniques of synthesis of high Tc superconductors would also be studied.

**CONTENTS**
Introduction: Development in the field of superconductivity, Basic parameters of superconductivity, Types of superconductors, BCS theory, Meissner Effect, Josephson effect in Superconductors. High Tc Superconductors, Cuprate Superconductors, La, Y, Bi, Tl and Hg based superconductors, Intermetallic MgB2 superconductor crystal structure and superconducting properties, conduction mechanism. Synthesis of High Tc superconductors Different methods of synthesis of High Tc superconductors: Electrodeposition, electrophoretic method, spray pyrolysis technique, solid state reaction method, screen
printing, Pulse laser deposition method (PLD), Powder in tube method (PIT), combustion method, sol-gel method, Electrodeposition of alloys: DC electrode position, Mechanism of electrodeposition, Post deposition treatments. Applications of Superconductors in Energy Superconducting wires and their characteristics, High field magnets for production of energy by magnetic fusion, Energy generation-Magnetohydrodynamics (MHD), energy storage, electric generators and role of superconductors. Large scale applications of superconductors Electric power transmission, Applications of superconductor in the magnetism and medicine Magnetic Resonance Imaging (MRI), Superconducting Quantum Interference Devices (SQUID), Experimental Techniques, Low temperature resistivity measurements: Four probe and Vander Paw resistivity technique, AC and DC susceptibility measurements, SQUID measurements, Different types of cryostat, Closed cycle refrigerators system.

**BOOKS RECOMMENDED**


**Elective course-II (B)**

<table>
<thead>
<tr>
<th>RE-486</th>
<th>Energy Efficient Buildings</th>
<th>3(3-0)</th>
</tr>
</thead>
</table>

**PRE-REQUISITE:** Elective course-I: B (Solar Passive Architecture)

**OBJECTIVE**

To promote energy efficient building design to minimize energy use and to maximize the renewable and natural resources in building environment

**CONTENTS**


**BOOKS RECOMMENDED**


**Elective course-II (C)**

<table>
<thead>
<tr>
<th>RE-487</th>
<th>Fabrication of Solar Cells</th>
<th>3(3-0)</th>
</tr>
</thead>
</table>

**PRE-REQUISITE:** Elective course-I: A (Thin Film Technology and Applications)

**OBJECTIVE**

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To train students about the use of different materials for the fabrication of photoactive
materials in Nano scale which possess maximum ability to harvest the sun light in visible
region. Furthermore, the working and principles as well as the characterization of solar cells.
In the practical domain the use of potentio-stat and cyclic voltammetry is prime importance.

**CONTENTS**

Introduction to Solid State Physics and Chemistry, Fabrication of nanostructure materials
using semiconductor oxides, sulphides etc. Principles for measuring the band gap of
semiconductors materials. Strategies to manufacture different morphologies of photoactive
materials. Characterization of photoactive materials using spectroscopy, microscopy (SEM,
TEM) and X-ray diffraction. Measurement of current voltage characteristics of the solar
cells. Basics of Crystallography. Basic principles of electrochemistry, Role of electrolytes in
the formation of the photovoltaic cells. Types of electrolytes and their limitations. Photo
electrochemical cell. Electrodes and their selection. Dark current and light current. Concept
of recombination of charges. Forward and reverse biasing.

**PRACTICALS**

Photometric measurement, preparation of their films of photoactive materials, measurement
of conductance, surface area demonstration, light intensity measurement.

**BOOKS RECOMMENDED**

2. Christopher, M.A.B. and A. M. Bret. Electrochemistry Principles, Methods, and
   Application, Oxford University Press, Latest edition
3. McHardy, J. and F. Ludwig. Electrochemistry of Semiconductor and Electronics,
   William Andrew Publications, USA, Latest edition