SIX MONTH CERTIFICATE, ONE YEAR POST GRADUATE DIPLOMA AND TWO YEAR M. Sc IN SOLAR ENERGY

SYLLABUS

CREDIT SYSTEM

&

GRADING SYSTEM

UNDER

GAUHATI UNIVERSITY :: GUWAHATI

&

POGL GROUP OF INSTITUTIONS,

Institution of Engineers, 3rd Floor, Panbazar, Ghy-01

GAUHATI UNIVERSITY :: GUWAHATI

SYLLABUS OF ONE YEAR POST GRADUATE DIPLOMA AND TWO YEAR MSc SOLAR ENERGY COURSE

SEMESTER-WISE COURSE STRUCTURE

SEMESTER I:

Code No	Paper Name	Univ. Marks	Internal marks	Total Marks
1.1	Introduction to Renewable Energy, Its Sources & future Prospects	100	25	125
1.2	Basics of Solar Radiation	100	25	125
1.3	Solar Thermal Energy & Its Storage	100	25	125
1.4	Projects and practical	Report 75+ External 25= 100	25	125
Total		400	100	500

Paper I: Introduction to Renewable Energy, Its Sources & Future Prospects:

Definition of energy, kinds of energy, different sources of energy, their merits and reserves, renewable energy sources, energy services and efficiency improvement, energy in a sustainable future, indirect and direct solar energy, Indirect sources: wind, water at high places, ocean, Biomass, nuclear power, geothermal energy, Direct Sources: Heat and light from the sun.

Paper II: Basics of Solar Radiation:

Solar radiation: introduction, solar system-sun, earth, and earth-sun angles, time, derived sun angles, absorption, radiation and conversion of thermal energy, estimation of solar radiation (direct and diffuse), measurement systems- phyrheliometers and other devices, The sun as the source of energy, the solar constant, special distribution of extraterrestrial radiation, effects of atmosphere on solar radiation, diffuse radiation at

the ground, average global and diffuse radiation on a clear day, computation of radiation energy on inclined surfaces, methods of measurements of diffuse, global and direct solar radiation. Effects of solar radiation upon structures, steady state heat transmission, solar radiation properties of surfaces, periodic heat transfer through walls and roofs.

Paper III: Solar thermal energy & Its Storage:

Solar thermal energy : Processes of conduction of heat, low, medium and high temperature collectors, types of solar energy collectors: solar flat plate collectors, materials for flat plat collectors, differences of air and liquid heat collectors, efficiency of flat plate collectors

Solar Thermal energy storage:

Heat storage, storage media, steam accumulator, other storage systems, heat exchangers and applications of stored energy.

Need of thermal energy storage, size and designs of heat storage, different storage systems, novel designs of solar air heaters, Solar ponds.

IV. Project:

Preparation of a project with external and internal assessment

SEMESTER II:

Code No	Paper Name	Univ. Marks	Internal marks	Total Marks
2.1	Optical Engineering & Solar Collectors	100	25	125
2.2	Basics of Solar Photovoltaics (PV)	100	25	125
2.3	Liquid Based & Other Solar Devices	100	25	125
2.4	Project and practicals	Report 75+ External 25=100	25	125
Total		400	100	500

Paper I: Optical engineering and Solar Collectors:

Unit I: Optical design, anti-reflection coatings, beam splitters, surface structures for maximum light absorption, operating temperature vs conversion efficiency.

Unit II: Types of solar energy concentrators, Fresnel lenses and Fresnel reflectors, operating solar cells at high incident energy for maximum power output, Flat plate and concentrating solar collectors-comparative study, design and materials, efficiency, selective coatings, heliostats, Parameters characterizing solar concentrators, materials for solar concentrators, thermodynamic limits of concentrators.

Paper II: Basics of Solar Photovoltaics (PV):

Unit I: Fundamentals of solar cells: semiconducting materials, absorption of radiation by semiconductors, band gap theory, band engineering,

Unit II: Solar cell properties and design: requirements of metal- p-n junction photodiodes, depletion region, electrostatic field across the depletion layer, electron-hole generation, device physics, charge carrier generation, recombination and other losses, I-V characteristics, output power, spectral response of a solar cell.

Unit III: solar cell materials, types of solar cells: single crystal, polycrystalline and amorphous solar cells, cadmium telluride thin-film solar cells, conversion efficiency, - their applications,

Unit IV: Single junction and triple-junction solar panels, , reducing costs and raising efficiency, thin film PV, other innovative PV technologies, electrical characteristics of solar PV cells and modules.

Unit V: Solar cell applications: PV cell interconnections: parallel and series connections of solar cells, module structure and module fabrication

equivalent circuits and efficiency of solar cell, load matching, fill factor and optimization for maximum power,

Unit VI: solar panels, storage batteries, basics of lead acid batteries, electronic controller, inverters, maintenance of battery, cleanliness, adding water, kind of water, discharge limits, hydrometer readings- specific gravity, readings-written records,

Paper III: Liquid- based & other solar devices:

Liquid- based solar devices:

Solar water heaters, natural circulation type, built-in type, the rooftop solar water heater, the pumped solar water heater, the thermosyphon solar water heater, mathematical models of water heaters, solar ponds, swimming pools heating, design of solar pool

heating systems, construction and types of solar collectors for pool heating system, factors to consider

Solar devices:

Solar cookers, different types of cookers- flat plate and box type solar cooker, concentrator type solar cooker and basket type solar cooker, testing of solar cookers, advantages of solar cookers, limitations, cooking time, precautions while using a solar cooker, Solar drying, types of Solar dryers, natural convection type dryers, forced circulation type dryers, Solar stills, desalination, Solar drying of foods, Solar furnaces, heliostats, sun tracking, typical Solar furnace designs.

IV. Project Report & Practical:

Preparation of a project with external and internal assessment

After Completion of Semester I and Semester II, Students will be offered Post Graduate Diploma in Solar Energy (PGDSE)

After completion of 1st and 2nd semester for PGDSE, students are eligible to continue in 3rd semester and 4th semester for MSc Solar Energy

SEMESTER III:

Code No	Paper Name	Univ. Marks	Internal marks	Total Marks
3.1	Solar Photovoltaic Power Systems	100	25	125
3.2	Solar Thermo-mechanical Technology	100	25	125
3.3	Solar Wind Power & Its Application	100	25	125
3.4	Projects and practicals	Report 75 + External 25= 100	25	125
Total		400	100	500

Paper I: Solar Photovoltaic (PV) Power systems:

Unit I: PV power systems: principles, PV systems for remote power, grid-connected PV systems, Back-up PV system, solar PV street lighting system, system sizing, device structures, device construction, installation, measurements, DC to AC conversion, cost of energy from PV, Satellite Solar Power systems, PV integration, resources and future prospects. Photovoltaic system design guidelines and methodologies. Trouble shooting,

Unit II: Photoelectrochemical cells for hydrogen production:

a. Photoelectrochemical electrolysis, Photoelectrochemical cells for hydrogen production, solar-to-hydrogen efficiency.

b. Hydrogen storage, hydrogen economy.

Unit III: Solar cell manufacturing processes: material resources, chemistry, and environmental impacts, low cost manufacturing processes.

Current trends in photovoltaic research and applications; nanotechnology applications, quantum dots, solution based processes solar cell production.

Unit IV: Thermoelectric systems:

a. Thermoelectricity, Peltier effect, Seebech effect;

b. Thermoelectric materials, Bismuth telluride, automotive thermoelectric generators, radiosotopie thermoelectric generator.

c. Thermoelectric power generators, thermoelectric refrigerators, and heat pumps.

Paper II: Solar Thermo-mechanical Technology:

Unit I: Principle of solar engines, Solar heat engines, turbines,

Unit II: Solar stirling engines: General principles, configuration- Mechanical configurations, low temperature differential engine, principle of operation-stirling cycle, stirling engine operation, motion diagram, stirling engine efficiency, engine indicated work, engine power output, development of stirling engines, development of solar powered stirling engines, development of LTD stirling engines

Unit III: Brayton engines: Brayton cycle, model, solar Brayton cycle, methods to increase power and efficiency. Reverse Brayton cycle

Unit IV: Solar thermal electric generation plants, economics, potential and environmental impacts.

Paper III: Solar Wind Power & Its Application:

Unit I:Some parameters of wind, wind electricity: challenges and opportunities, wind speed and power relation, rotor swept area, wind speed distribution, Weibull probability distribution, mode and mean speeds, root mean cube speed, digital data loggers, effect of height, wind speed prediction, characteristics of wind power –design of wind mills,

Unit II: Wind power system: system components- tower, turbine blades, Yaw control, speed control, turbine rating, wind mills, aero turbines, electrical generators- the direct current machine, synchronous machine, induction machine, construction, working principle, equivalent circuit for performance calculations, efficiency and cooling, Self-excitation capacitance, torque-speed characteristic, transients, variable-speed operation, speed control regions, generator drives, drive selection, Cut-out speed selection, System design features-number of blades, rotor upwind or downwind, horizontal axis/vertical axis, spacing of the towers, Maximum power operation-constant tip-speed ration scheme, peak power tracking scheme; System control requirements: speed control, rate control; Environmental aspects,

Unit III: Energy storage technology: electrochemical battery, flywheel, compressed air, superconducting coil; types of batteries, equivalent electrical circuit, performance characteristics, Battery design, battery charging, regulators, battery management,

Unit IV:Flywheel: system components, benefits over battery,

Unit V: Compressed air technology: components; Superconducting coil:

IV. Project & Practical:

Preparation of a project with external and internal assessment

SEMESTER IV:

Code .No	Paper Name	Univ. Marks	Internal marks	Total Marks
4.1	Design of Solar Houses & Implementation Principles	100	25	125
4.2	Solar Heating, Cooling & Air-conditioning Systems	100	25	125
4.3	Solar Energy & Environment	100	25	125
4.4	Projects & Practical	Report 75+ External 25=100	25	125
Total		400	100	500

Paper I: Design of Solar houses & Implementation Principles:

Passive systems: Definition, building designs, thermal storage walls, thermal storage roofs, attached green house, convective loops, shading, ventilation, evaporation, cooling, elements of passive solar architecture.

Paper II: Solar Heating, Cooling & Air-Conditioning Systems:

Unit I: Design of active systems by f-chart and utilizability methods, Solar heating, heating applications of solar energy: air and water heating systems, types of solar water heating systems: (i) active solar water heating systems-(a) direct circulation systems (or open systems), (b) indirect circulation systems (or closed systems), (c) drainback systems; (ii) Passive solar water heating systems: (a) integral-collector storage systems, (b) thermosyphon systems; components of solar heating systems (e.g. collectors, storage tank, solar panels, pump and controls, flow meter, temperature gauge, solar by-pass valve, tempering valve, glycol, temperature and pressure relief valve, high limit switch, solar loop pressure relief valve, etc.), sizing a solar water heating system, system design requirements, collectors: batch collectors, flat plat collectors, and evacuated tube collectors, types of heat exchangers: (i) liquid-to- liquid heat exchangers, and (ii) air-to-liquid heat exchangers; Heat exchanger designs : 1. Coil-in-tank heat exchanger, 2. Shell-and-tube heat exchanger, 3. Tube-in-tube heat exchanger, heat exchanger sizing, criteria for selecting heat transfer fluids, types of heat transfer fluids, system installation, test, and troubleshooting. House heating by solar air systems, liquid systems, solar water pumps: types of pumps- circulating pumps, submersible pumps, surface pumps, delivery pumps. Determining the type of pump one needs.

Unit II:Solar cooling and air conditioning: Continuous and intermittent vapour absorption systems for Cooling applications, absorbent- refrigerant combinations.

Unit III: Solar energy for industrial purposes: Solar heating, drying: combined type solar dryer, bamboo type solar dryer, water supply, power, solar refrigeration,

Paper III: Solar energy and Environment:

Unit I: Adverse effects of using fossil fuels (Coal, oil, gas), geothermal energy: an overview, the physics of geothermal resources, technologies for geothermal resource exploitation, environmental implications, economics and world potential, nuclear energy, fusion, solar thermal energy, solar panels, wind power generation, hydropower, biomass: bio conversion mechanism- utilization of photosynthate, thermal storage, batteries etc. safety procedures,

Unit II: Economic Scenario, Ozone Layer Depletion, Green House effect, Global Warming, Remedial Measures by International Bodies.

Unit III: Solar energy cost analysis and environmental issues:

1. Cost analysis and pay back calculations for different types of solar panels and collectors, installation and operating costs.
2. Environmental and safety issues, protection systems, performance monitoring.

Unit IV: Policy, Programs, Regulations etc. Policy Support for Grid Interactive Renewable Power: Electricity Act 2003, National Electricity Policy 2005, Tariff Policy 2006, National Rural Electrification Policies 2006, Renewable Power Policies, Grid Interactive and Off Grid/Distributed Renewable Power, other support programmes of MNRE. Energy and climate change, Regulatory issues of coal, oil and gas, nuclear and hydro energy

IV. Project:

Preparation of a project with external and internal assessment

Experiments and Projects are to be related to course:

Creditization of Course:

1 Credit = 3 Hours.

Total Credit/Sem = 34 (34 X 3=102 Hrs)

For Semester I:

Paper Name	Hours Assigned			Credits Assigned		
	Theory	Practice	Total	Theory	Practice	Total
Introduction to Renewable Energy & Its Sources	18	6	24	6	2	8
Basics of Solar Radiation	18	6	24	6	2	8
Solar Thermal Energy & Its Storage	18	6	24	6	2	8
Projects		30	30		10	10

For Semester II:

Paper Name	Hours Assigned			Credits Assigned		
	Theory	Practice	Total	Theory	Practice	Total
Optical Engineering & Solar Collectors	18	6	24	6	2	8
Basics of Solar Photovoltaics (PV)	18	6	24	6	2	8
Liquid Based & Other Solar Devices	18	6	24	6	2	8
Projects		30	30		10	10

For Semester III:

Paper Name	Hours Assigned			Credits Assigned		
	Theory	Practice	Total	Theory	Practice	Total
Solar Photovoltaic Power Systems	18	6	24	6	2	8
Solar Thermo-mechanical Technology	18	6	24	6	2	8
Solar Wind Power & Its Application	18	6	24	6	2	8
Projects		30	30		10	10

For Semester IV:

Paper Name	Hours Assigned			Credits Assigned		
	Theory	Practice	Total	Theory	Practice	Total
Design of Solar Houses & Implementation Principles	18	6	24	6	2	8
Solar Heating, Cooling & Air-conditioning Systems	18	6	24	6	2	8
Solar Energy & Environment	18	6	24	6	2	8
Projects		30	30		10	10

Grading System:

- Rel. percentage Score = (100/Highest marks) x Actual Marks

RPS	Letter Grade	Grade Point
90 -100	A	10
75 – 89	B	8
55 -74	C	6
40 -54	D	4
30 – 39	E	2
AM/ RPS <30	F	0