DAV UNIVERSITY JALANDHAR

Course Scheme For

M. Tech Solar power Engineering
(Program ID-75)

1st TO 4th SEMESTER
Examinations 2014–2015 Session Onwards

Syllabi Applicable For Admissions in 2014

Scheme of Courses M.Tech

M. Tech Solar power Engineering

Semester 1

S.No.	Paper Code	Course Title	L	T	P	Cr	% Weightage				E
							A	B	C	D	
1	SPE501	Solar Radiation and Energy Conversion	4	0	0	4	25	25	25	25	**100**
2	SPE502	Thermodynamics & Heat Transfer in Solar Systems	4	0	0	4	25	25	25	25	**100**
3	SPE503	Photovoltaic Science & Solar Photovoltaic Systems	4	0	0	4	25	25	25	25	**100**
4	MGT551	Research Methodology	4	0	0	4	25	25	25	25	**100**
5	SPE504	Fuel Cell and Hydrogen Technology	4	0	0	4	25	25	25	25	**100**
6	SPE505	Solar Radiation and Energy Conversion Laboratory	0	0	8	4	20	80			**100**
			20	0	**8**	**24**					**600**

Semester 2

S. No	Paper Code	Course Title	L	T	P	Cr	% Weightage				E
							A	B	C	D	
1	SPE511	Structural Analysis and Design of Solar Systems	4	0	0	4	25	25	25	25	**100**
2	SPE512	Solar Energy Engineering	4	0	0	4	25	25	25	25	**100**
3	SPE513	Nano Materials Science for Solar Applications	4	0	0	4	25	25	25	25	**100**
4	SPE514	Energy Efficient Buildings and Systems	4	0	0	4	25	25	25	25	**100**
5	SPE515	Structural Analysis and Design of Solar Systems Laboratory	0	0	8	4	20	80			**100**
6	SPE516	Solar Energy Engineering Laboratory	0	0	8	4	20	80			**100**
Total			**16**	**0**	**16**	**24**					**600**

A: Continuous Assessment: Based on Objective Type Tests
B: Mid-Term Test-1: Based on Objective Type & Subjective Type Test
C: Mid-Term Test-2: Based on Objective Type & Subjective Type Test
D: End-Term Exam (Final): Based on Objective Type Tests
E: Total Marks

L: Lectures T: Tutorial P: Practical Cr: Credits

Scheme of Courses M.Tech

M. Tech Solar power Engineering

Semester 3

S.No.	Paper Code	Course Title	L	T	P	Cr	% Weightage				E
							A	B	C	D	
1	SPE621	Control and Drives for Solar Systems	4	0	0	4	25	25	25	25	**100**
2	SPEXXX	Special Elective-I	4	0	0	4	25	25	25	25	**100**
3	SPEXXX	Special Elective-II	4	0	0	4	25	25	25	25	**100**
4	SPE622	Advanced Simulation Laboratory	0	0	4	4	25	25	25	25	**100**
5	SPE623	Research Seminar	0	0	8	4	20	80			**100**
6	SPE624	**Dissertation-I** (Literature Survey and Problem Formulation)	0	0	8	4	20	80			**100**
			12	**0**	**20**	**24**					**600**

Note: Presentation and Viva-Voce will be conducted for the Dissertation-I at the end of semester-III and topic of Dissertation, Problem Formulation and Research Objectives along with the methodology adopted will be recommended by the committee of Supervisor(s) or Research Degree Committee (RDC).

A: Continuous Assessment: Based on Objective Type Tests
B: Mid-Term Test-1: Based on Objective Type & Subjective Type Test
C: Mid-Term Test-2: Based on Objective Type & Subjective Type Test
D: End-Term Exam (Final): Based on Objective Type Tests
E: Total Marks

L: Lectures T: Tutorial P: Practical Cr: Credits

Scheme of Courses M.Tech

M. Tech Solar power Engineering

Semester 4

S.No.	Paper Code	Course Title	L	T	P	Cr	% Weightage				E
							A	B	C	D	
1.	ELE625	**Dissertation-II** (Analysis, Result & Discussion and Conclusion)	0	0	48	24	20	80			**600**
			0	**0**	**48**	**24**					**600**

Note: Presentation and Viva-Voce will be held for Dissertation-II at the end of the semester-IV and SATISFACTORY/UNSATISFACTORY grade will be awarded by the committee of Supervisor(s) or Research Degree Committee (RDC) after Viva-Voce of Dissertation-II.

SPECIAL ELECTIVE-I		
S.No.	**Paper Code**	**Subject Name**
1.	SPE651	Advanced Thermodynamics
2.	SPE652	Energy Conversion Systems
3.	SPE653	Soft Computing Techniques
4.	SPE654	Design of Equipment's For Energy Conversion Systems
5.	SPE655	Materials Science And Tribology For Energy Conversion Systems
6.	SPE656	Optimization Techniques
SPECIAL ELECTIVE-II		
S.No.	**Paper Code**	**Subject Name**
1.	SPE657	Advanced Solar Engineering
2.	SPE658	Nuclear Engineering
3.	SPE659	Nano Science And Technology
4.	SPE660	Energy Conservation & Heat Recovery Systems
5.	SPE661	Energy Modeling, Economics And Management
6.	SPE662	Solar Energy Systems

Course Title: Solar Radiation and Energy Conversion
Paper Code: SPE501

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: The major objectives of this course to educate students in the design and applications of solar energy technology. It will focus on fundamentals of solar energy conversion and Radiation, Thermoelectric Systems, Solar Thermal Conversion and solar cells.

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Solar Energy Conversion: Photovoltaic, Photoelectrochemical, Photothermal and Thermoelectric systems, Solar energy: solar insolation vs. world energy demand, current energy consumption from different sources, environmental and health effects; Sustainable Energy: production and storage, resources and utilization.

Unit-B: Thermoelectric Systems: Thermoelectricity, Peltier effect, Seebeck effect; Thermoelectric materials, Bismuth telluride, automotive thermoelectric generators, radioisotope thermoelectric generator; Thermoelectric power generators, thermoelectric refrigerators and heat pumps

Unit-C: Solar Thermal Conversion: 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.

Unit-D: Solar Cell Applications: PV cell interconnection, module structure and module fabrication, Equivalent circuits, load matching, efficiency, fill factor and optimization for maximum power; Design of stand-alone PV systems, system sizing, device structures, device construction, installation, measurements; DC to AC conversion, inverters, on-site storage and grid connections; Solar cell manufacturing processes: material resources, chemistry, and environmental impacts; low cost manufacturing processes.

Suggested Books:

1. Martin A. Green , "Solar Cells: Operating Principles, Technology and system Applications", Published by the University of New South Wales, 1998, ISBN 0 85823 5803.
2. D. Yogi Goswami , "Principles of Solar Engineering", Taylor and Francis, 2000, ISBN 10: 1-56032-714-6.
3. Stuart Wenham, Martin Green, and Muriel Watt , "Applied Photovoltaics", Earthscan, 2007, ISBN 1-84407-407-3.
4. F. Lasnier and T. G. Ang , "Photovoltaic Engineering Handbook", IOP Publishing UK (Adam Hilger USA) 1990, ISBN 0-85274-311-4.
5. S. M., Sze , "Semiconductor Devices, Physics, and Technology", Second Edition, New York, NY: Wiley, 2001. ISBN: 0471874248.

Course Title: Thermodynamics & Heat Transfer in Solar Systems
Paper Code: SPE502

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: The major objectives of this course to educate students about Thermodynamics and heat transfer in Solar Systems. It will focus on fundamentals of Thermodynamics, Heat Transfer and Solar Systems.

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Laws of Thermodynamics
Energy, enthalpy, specific heats, first law applied to systems and control volumes, steady and unsteady flow analysis, Second Law of Thermodynamics: Kelvin-Planck and Clausius statements, reversible and irreversible processes, Carnot theorems, thermodynamic temperature scale, Clausius inequality and concept of entropy, principle of increase of entropy; availability and irreversibility.

Unit-B: ThermodynamicRelations
T-ds relations, Maxwell equations, Joule-Thomson coefficient, coefficient of volume expansion, adiabatic and isothermal compressibilities, Clapeyron equation, *Thermodynamic cycles:* Carnot vapor power cycle, Ideal Rankine cycle, Rankine Reheat cycle, Air standard Otto cycle, Air standard Diesel cycle, Air-standard Brayton cycle, Vapor-compression refrigeration cycle, Introduction to vapor power cycles, Air-standard power cycles, heat pump cycles.

Unit-C: Heat Transfer and Thermodynamic Processes
Dalton's and Amagat's laws, calculations of properties, air-water vapor mixtures and simple thermodynamic processes involving them., Control volume analyses for steady state and transient processes, Isentropic efficiencies of turbines, nozzles, compressors, and pumps

Unit-D: Solar Systems Designing
Solar indirect water heaters, solar collectors, solar controllers, solar pump stations, Solar piping & more, eco hybrid solar box

Suggested Books:

1. Bent, Henry A. , "*The Second Law: An Introduction to Classical and Statistical Thermodynamics",* Oxford University Press, 1965.
2. Fermi, Enrico, "*Thermodynamics*", New York: Dover Publications, 1936.
3. Shrodinger, Edwin, "*Statistical Thermodynamics*", Dover, 1989
4. U.S. Department of Energy Fundamentals Handbook Thermodynamics, Heat Transfer and Fluid Flow, Volume 1.
5. Howard DeVoe , "Thermodynamics and Chemistry", 2nd Edition, University of Maryland
6. Devereux, Owen F, "*Topics in Metallurgical Thermodynamics*", NY: John Wiley and Sons, 1983.
7. Gaskell, David R., "*Introduction to Metallurgical Thermodynamics*", NY: McGraw-Hill, 2nd edition, 1981.
8. Gibbs, J. Willard. "On the equilibrium of heterogeneous substances." (1876). In *Collected Works* 1, Longmans, Green, and Co., 1928.
9. Lifshitz, E.M., and L.P. Pitaevskii, " *Statistical Physics",* 3rd edition. Part 1. New York: Pergammon Press, 1980.
10. Planck, Max, "*Treatise on Thermodynamics*", 7th edition. New York: Dover Publications, 1926.

Course Title: Photovoltaic Science & Solar Photovoltaic Systems
Paper Code: SPE503

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: The major objectives of this course to educate students about Photovoltaic Science & Solar Photovoltaic Systems and their applications.

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Optical Engineering and Photovoltaic Science

Optical design, anti-reflection coatings, beam splitters, surface structures for maximum light absorption, operating temperature vs conversion efficiency; Types of solar energy concentrators, Fresnel lenses and Fresnel reflectors, operating solar cells at high incident energy for maximum power output.

Unit-B: Thin film Solar Cells and Photovoltaics (PV)

Single crystal, polycrystalline and amorphous silicon solar cells, cadmium telluride thin-film solar cells, conversion efficiency; Current trends in photovoltaic research and applications; nanotechnology applications, quantum dots, solution based processes solar cell production, 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 heterojunctions and semiconducting materials for solar cells.

Unit-C: Photo thermal Systems

Flat Plate Collector, Hot Air Collector, Evacuated Tube Collector, Parabolic, Compound Parabolic and Fresnel Solar Concentrators, Central Receiver System, Thermal Analysis of Solar Collectors Performance of Solar Collectors, Solar Water Heating Systems(Active & Passive), Solar Space Heating & Cooling Systems, Solar Industrial Process Heating Systems, Solar Dryers & Desalination Systems, Solar Thermal Power Systems

Unit-D: Photovoltaic systems

Solar cells & panels, performance of solar cell, estimation of power obtain from solar power, Solar panels PV systems, components of PV systems, performance of PV systems, design of PV systems, applications of PV systems, concentrating PV systems, PV power plants, power plant with fuel cells

Suggested Books:

1. Antonio Luque, Steven Hegedus , "Handbook of Photovoltaic Science and Engineering", 2nd Edition, ISBN: 978-0-470-72169-8.

2. Adolf Goetzberger, Volker Uwe Hoffmann, "Photovoltaic Solar Energy Generation", Springer, 31-May-2005.

Course Title: Fuel Cell and Hydrogen Technology
Paper Code: SPE504

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: The major objectives of this course to educate students about Fuel Cell and Hydrogen Technology and their applications.

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Introduction to Fuel Cells
Introduction – working and types of fuel cell – low, medium and high temperature fuel cell, liquid and methanol types, proton exchange membrane fuel cell solid oxide, hydrogen fuel cells –thermodynamics and electrochemical kinetics of fuel cells.

UNIT –B: Fuel Cell Components and Their Impact on Performance
Fuel cell performance characteristics – current/voltage, voltage efficiency and power density, ohmic resistance, kinetic performance, mass transfer effect– membrane electrode assembly components, fuel cell stack, bi-polar plate, humidifiers and cooling plates.

UNIT – C: Fuel Cycle Analysis and Hydrogen Technology
Hydrogen storage technology – pressure cylinders, liquid hydrogen, metal hydrides, carbon fibers – reformer technology – steam reforming, partial oxidation, auto thermal reforming – CO removal, fuel cell technology based on removal like bio-mass, Introduction to fuel cycle analysis – application to fuel cell and other competing technologies like battery powered vehicles, SI engine fueled by natural gas and hydrogen and hybrid electric vehicle.

Unit-D: Fuel Cells For Automotive Applications
Fuel cells for automotive applications, technology advances in fuel cell vehicle systems, onboard hydrogen storage, liquid hydrogen and compressed hydrogen, metal hydrides, fuel cell control system, alkaline fuel cell, road map to market.

Suggested Books:

1. "Fuel Cell Technology Handbook"- SAE International Gregor Hoogers CRC Press, ISBN 0-8493-0877-1-2003.
2. "Fuel Cells for automotive applications", Professional Engineering Publishing UK., ISBN 1-86058 4233, 2004.

Course Title: Research Methodology
Course Code: MGT551

L	T	P	Credits	Marks
4	0	0	4	100

Course Objective: The course is designed to introduce the students to research methodology and application of research techniques and procedures. The primary goal of this course is to develop a sound understanding of research methods.

Learning Outcomes: The students will be able to apply the various research methods by using computerized data analysis softwares to solve the real life problems.

Unit – A

- **Introduction to Research**: Meaning of Research, Objectives of Research, Types of Research, Research Approaches, Significance of Research, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India. — 2 hour
- **Defining the Research Problem**: What is a Research Problem?, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem — 1 hour
- **Research Design**: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, factors affecting RDs, Relation among RDs, Developing a Research Plan. — 2 hour

Unit – B

- **Sampling design and Procedures**: Sample or Census, The Sampling Design Process, A Classification of Sampling Techniques, Choosing Nonprobability Versus Probability Sampling, Uses of Non probability Versus Probability Sampling. — 2 hours
- **Measurement and Scaling**: Non-comparative Scaling Techniques, Continuous Rating Scale, Itemized Rating Scale, Non-comparative Itemized Rating Scale Decisions, Multi-item Scales, Scale Evaluation, Choosing a Scaling Technique. — 3 hours
- **Methods of Data Collection:** Collection of Primary Data, Observation Method, Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules, Some Other Methods of Data Collection, Collection of Secondary Data, Selection of Appropriate Method for Data Collection. — 3 hours
- **Questionnaire & form design**: questionnaire & observation forms, questionnaire design process. — 2 hours

Unit – C

- **Data preparation:** editing, coding, transcribing — 1 Hours
- **Data analysis**: tests of significance based on t, f and z distribution and chi-square test; cross tabulation — 3 hours
- **Multiple Regressio**n: Overview of Multiple Regression, Statistics Associated with Multiple Regression, Conducting Multiple Regression, Stepwise Regression, Multicollinearity — 3 hours
- **Discriminant Analysis**: Discriminant Analysis Model, Statistics Associated with Discriminant Analysis, Conducting Discriminant Analysis — 4 hours
- **Conjoint Analysis**: Basic Concepts in Conjoint Analysis, Statistics Associated with Conjoint Analysis, Conducting Conjoint Analysis, Assumptions & Limitations of Conjoint Analysis, Hybrid Conjoint Analysis — 4 hours

Unit – D

- **Multi Dimensional Scaling**: Basic Concepts in Multidimensional Scaling (MDS), Statistics Associated with MDS, Conducting Multidimensional Scaling, Selecting an MDS Procedure, Deciding on the Number of Dimensions, Labeling the Dimensions & Interpreting the Configuration, Assessing Reliability and Validity, Assumptions & Limitations of MDS, Scaling Preference Data — 3 hours
- **Correspondence Analysis**: Relationship between MDS, FA, & DA — 2 hours
- **Factor Analysis:** Factor Analysis Model, Statistics Associated with Factor Analysis, Conducting Factor Analysis, Applications of Common Factor Analysis — 3 hour
- **Cluster Analysis**: Statistics Associated with Cluster Analysis, Conducting Cluster Analysis, Applications of Non-hierarchical Clustering, Clustering Variables. — 5 hours
- **Research Report Writing**: Contents of Report, Executive Summary, Bibliography format. Presentation of Report. — 2 hour

Total 45 hours

Reference Books:

1. Bajpai Naval, "*Business Research Methods"*, Pearson Publications.
2. Malhotra, Naresh K., "*Marketing Research: An Applied Orientation"*, 5th Edition. Pearson/Prentice-Hall, 2007
3. Proctor Tony, "*Essentials of Marketing Research"*, 4th Edition, Prentice Hall.
4. Beri G. C., "*Marketing research"*, 4th Edition, Mcgrawhill.
5. C.R Kothari, "*Research Methodology"*, New Age Publishers

Course Title: Solar Radiation and Energy Conversion Laboratory
Paper Code: SPE505

L	T	P	Credits	Marks
0	0	8	4	100

List of Experiments

1. Study of direct and diffused beam solar radiation
2. Study of Green House Effect
3. Performance evaluation of solar flat plate collector
4. Study the effect of solar flat plate collector in parallel combination
5. Performance evaluation of concentrating solar collector
6. Performance evaluation of solar cooker
7. Performance evaluation of a solar PV panel
8. Performance of PV panel in series and parallel combination
9. Charging characteristics of a battery using PV panel
10. Effect of tilt angle on solar PV panel
11. Effect of shadow on solar PV panel
12. Effect of surrounding temperature on PV panel
13. Performance evaluation of solar funnel

Course Title: Structural Analysis and Design of Solar Systems
Paper Code: SPE511

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: The major objectives of this course to educate students about Design and Structural Analysis of Solar Systems.

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Introduction: Modeling of an electrical system/micro grid, Models layout, Photovoltaic systems, Irradiance and solar radiation, solar radiation availability, Types of PV systems.

Unit-B: Modeling the PV systems: Steady state models and dynamic models of PV-inverter units; Power Flow Analysis of PV units, Short Circuit Analysis of PV units, Security and Reliability Analysis of PV units, Numerical examples: power flow, short circuit, voltage regulation, security and reliability analysis and Case studies..

Unit-C: Modeling and Simulation: Introduction to modeling, a systematic approach to model building, classification of models, Conservation principles, thermodynamic principles of process systems, Development of steady state and dynamic lumped and distributed parameter models based on first principles. Analysis of ill-conditioned systems, Review of Current professional software on the market modeling for PV units, Modeling issues in PV, Standalone PV units, Grid connected PV units,

Unit-D: Control Blocks and Protection Systems: PV – Inverter systems; Dynamic models of PV-inverter units; Dynamic PV models; using Open Source Application Programming Interface - OSAPI; Large PV units modeling and analysis; PV units and impact to distribution systems; Design and Analysis procedures; Guideline for integration studies; determination of acceptable level of penetration of PV units; Case studies; Guide line in designing a PV distributed system.

Suggested Books:

1. Sohail Anwar, Harry Efstathiadis and Salahuddin Qazi, " Handbook of Research on Solar Energy Systems and Technologies"
2. Photovoltaics: Design and Installation Manual, Solar Energy International , Canada
3. *K. M. Hangos and I. T. Cameron, "Process Modelling and Model Analysis", Academic Press, 2001.*
4. *W.L. Luyben, "Process Modelling, Simulation and Control for Chemical Engineers", 2nd Edition, McGraw Hill Book Co., New York, 1990.*
5. *W. F. Ramirez, "Computational Methods for Process Simulation", Butterworths, 1995.*
6. *Mark E. Davis, "Numerical Methods and Modelling for Chemical Engineers", John Wiley & Sons, 1984.*
7. *Singiresu S. Rao, "Applied Numerical Methods for Engineers and Scientists" Prentice Hall, Upper Saddle River, NJ, 2001*
8. *Francis Vanek, Louis D. Albright, "Energy Systems Engineering," McGraw-Hill Book Company, N. Y. 2008*
9. *Power System Engineering 2nd Ed. D P Kothari, I. J. Nagrath, Tata McGraw-Hill Co 2008*

Course Title: Solar Energy Engineering
Paper Code: SPE512

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: The major objectives of this course to educate students about Solar Energy Engineering and their applications.

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Source of radiation, solar constant, solar charts, Measurement of diffuse, global and direct solar radiation: pyrheliometer, pyranometer, pyregeometer, net pyradiometer, sunshine recorder

Unit-B: Solar Non-Concentrating Collectors, Design considerations, Classification, air, liquid heating collectors, Derivation of efficiency and testing of flat plate collectors, Analysis of concentric tube collector , Solar green house.

Unit-C: Design, Classification, Concentrator mounting, Focusing solar concentrators, Heliostats, Solar powered absorption A/C system, water pump, chimney, drier, dehumidifier, still, cooker.

Unit-D: Photo-voltaic cell, characteristics, cell arrays, power electric circuits for output of solar panels, choppers, inverters, batteries, charge regulators, Construction concepts.
Energy Storage **-** Sensible, latent heat and thermo-chemical storage-pebble bed etc. materials for phase change, Glauber's salt, organic compounds, Solar ponds.

Suggested Books:

1. D. Yogi Goswami, Frank Kreith, Jan. F. Kreider, "Principles of Solar Engineering", 2nd Edition, Taylor & Francis, 2000, Indian reprint, 2003.
2. Edward E. Anderson, "Fundamentals for solar energy conversion", Addison Wesley Publication Co., 1983.
3. Duffie J. A and Beckman, W .A., "Solar Engineering of Thermal Process", John Wiley, 1991.
4. G. N. Tiwari and M. K. Ghosal, "Fundamentals of Renewable energy Sources", Narosa Publishing House, New Delhi, 2007
5. Energy Studies, Second Edition, by W. Shepherd and D. W. Shepherd, Imperial College Press, London, 2004.

Course Title: Nano Materials Science for Solar Applications
Paper Code: SPE513

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: The major objectives of this course to educate students about Nano Materials Science for Solar Applications.

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Design Considerations for Efficient and Stable Polymer Solar Cells: Introduction, Role of Interfacial Layer for Efficient BHJ Solar Cells, Selection of Interfacial Layer for Stable and Longer Lifetime, Materials Used as Interfacial Layer, Carbazole-Based Organic Dyes for Dye-Sensitized Solar Cells: Role of Carbazole as Donor, Auxiliary Donor and π-linker: Introduction, Carbazole as a Donor for Dye-Sensitized Solar Cells, Carbazole as a π-Linker, Carbazole as Auxiliary Donor for DSSC, Carbazole as Donor as Well as Linker for DSSC.

Unit-B: Colloidal Synthesis of CuInS2 and CuInSe2 Nanocrystals for Photovoltaic Applications: Introduction, Synthesis of CuInS2 and CuInSe2 Nanocrystals, Application of Colloidal CuInS2 and CuInSe2 Nanoparticles in Solar Energy Conversion, Two Dimensional Layered Semiconductors: Emerging Materials for Solar Photovoltaics: Introduction, Material Synthesis, Photovoltaic Device Fabrication, Microstructural and Raman Spectroscopic Studies of MoS2 and WS2, Photovoltaic Performance Evaluation, Electronic Transport and Interfacial Recombination

Unit-C: Control of ZnO Nanorods for Polymer Solar Cells: Introduction, Preparation and Characterization of ZnO NRs, Application of ZnO NR in Polymer Solar Cells, Introduction to Dye-Sensitized Solar Cells, Nanoimprint Lithography for Photovoltaic Applications

Unit-D: Indoor Photovoltaics: Efficiencies, Measurements and Design , Photon Management in Rare Earth Doped Nanomaterials for Solar , Advances in Plasmonic Light Trapping in Thin-Film Solar Photovoltaic Devices, Recent Research and Development of Luminescent Solar Concentrators, Luminescent Solar Concentrators – State of the Art and Future Perspectives, Organic Fluorophores for Luminescent Solar, PAn-Graphene-Nanoribbon Composite Materials for Organic Photovoltaics: A DFT Study of Their Electronic and Charge Transport Properties, Analytical Modeling of Thin-Film Solar Cells – Fundamentals and Applications, Efficient Organic Photovoltaic Cells: Current Global Scenario, Real and

Reactive Power Control of Voltage Source Converter-Based Photovoltaic Generating Systems

Suggested Readings:

1. Atul Tiwari , Rabah Boukherroub , Maheshwar Sharon, Solar Cell Nanotechnology, Scrivener publishing-Wiley, ISBN: 978-1-118-68625-6.

2. Hari Singh Nalwa, Nanomaterials for Energy Storage Applications, Journal of Nanoscience and Nanotechnology, USA

3. Tetsuo Soga, Nanostructured Materials for Solar Energy Conversion, Elseveir publication, ISBN: 978-0-444-52844-5.

Course Title: Energy Efficient Buildings and Systems
Paper Code: SPE514

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: The major objectives of this course to educate students about Energy Efficient Buildings and Systems.

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Architecture- Building Science and its significance, Indoor Environment, Components of Indoor Environment, Quality of Indoor Environment.

Unit-B: Human Comfort-Thermal, Visual, Acoustical and Olfactory comfort. Concept of Sol-air
temperature and its significance. Ventilation and is significance, Cooling and heating concepts, Passive concepts appropriate for the various climatic zones in India. Classification of building materials based on energy intensity.

Unit-C: Energy Management of Buildings and Energy Audit of Buildings. - Energy management matrix monitoring and targeting.

Unit-D: Energy Efficient Landscape Design **-**Modification of microclimate through landscape elements for energy conservation.

Suggested Books:

1. Sodha M.,Bansal, N.K., Bansal,P.K., Kumar, A.. and Malik, M.A.S., Solar Passive Buildings", Pergamon Press, 1986.
2. Koenigsberger, O.H., Ingersoll, T.G., Mayhew Alan and Szokolay, S. V., "Manual of Tropical Housing and Building part 1: Climatic Design", OLBN 0 00212 0011, Orient Longman Limited, 1973.
3. Bureau of Indian Standards, I.S. 11907 –1986 Recommendations for calculation of Solar Radiation Buildings, 1986.
4. Givoni,B., "Man, Climate and Architecture", Elsevier, Amsterdam, 1986.
5. Smith, R. J., Phillips, G.M. and Sweeney, M. "Environmental Science", Longman Scientific and Technical, Essex, 1982.

Course Title: Structural Analysis and Design of Solar Systems Laboratory
Paper Code: SPE515

L	T	P	Credits	Marks
0	0	8	4	100

Course Objectives: The major objectives of this course to import the practical knowledge about Structural Analysis and design of Solar Systems.

List of Experiments

1. Introduction to Open Source Application Programming Interface – OSAPI
2. Design of Steady state Model of PV-inverter units
3. Design of Dynamic models of PV-inverter units
4. Power Flow Analysis of PV units
5. Short Circuit Analysis of PV units
6. Security and Reliability Analysis of PV units
7. Development of steady state and dynamic lumped and distributed parameter models based on first principles.
8. Analysis of ill-conditioned systems
9. Large PV units modeling and analysis
10. Design and Analysis procedures; Guideline for integration studies
11. Determination of acceptable level of penetration of PV units

Course Title: Solar Energy Engineering Laboratory
Paper Code: SPE516

L	T	P	Credits	Marks
0	0	8	4	100

Course Objectives: The major objectives of this course to import the practical knowledge about Solar Energy Engineering and their applications.

List of Experiments

1. Study of direct and diffused beam solar radiation
2. Study of greenhouse effect
3. Performance evaluation of solar flat plate collector
4. Study the effect of solar flat plate collector in parallel combination
5. Performance evaluation of concentrating solar collector
6. Performance evaluation of solar cooker
7. Performance evaluation of a solar PV panel
8. Performance of PV panel in series and parallel combination
9. Charging characteristics of a battery using PV panel
10. Effect of tilt angle on solar PV panel
11. Effect of shadow on solar PV panel
12. Effect of surrounding temperature on PV panel
13. Performance evaluation of solar funnel

Course Title: Control and Drives for Solar Systems

Paper Code: SPE621

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: The major objectives of this course to educate students about Control and Drives for Solar Systems.

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/ MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Control in Solar Systems: Introduction to automatic control systems, Control issues related to energy conservation, Classification of HVAC control systems. Control system hardware: selection and sizing of sensors, actuators and controllers. Practical HVAC control systems; elementary local loop and complete control systems, Designing and tuning of controllers, Building automation systems.

Unit-B: Power Sources and Sensors: Hydraulic, pneumatic and electric drives , determination of HP of motor and gearing ratio, variable speed arrangements, path determination, laser , acoustic, magnetic, fiber optic and tactile sensors.

Unit-C: Control Drives for Solar Systems: Stepper Motors-Constructional features, Principle of operation, Modes of excitation torque production in Variable, Reluctance (VR) stepping motor, Switched Reluctance Motors, Control Techniques, Drive Concept, Permanent Magnet Brushless DC Motors Commutation in DC motors, Hall sensors, Optical sensors, Multiphase Brushless motor, Square wave permanent magnet brushless motor drives, Controllers-Microprocessors based controller.

Unit D: Permanent Magnet Synchronous Motors: Principle of operation, Power Controllers, Torque speed characteristics, Self-control, Vector control, Current control Schemes, Servomotor: Characteristics, Control –Microprocessor based applications, Linear Induction Motor (LIM).

Suggested Books:

1. Mikell P. Weiss G.M., Nagel R.N., Odraj N.G Industrial Robotics, McGraw-Hill Singapore. 1996
2. Miller, T.J.E. "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1989.
3. Kenjo, T, "Stepping Motors and their Microprocessor control", Clarendon Press, Oxford, 1989.
4. Naser A and Boldea I, "Linear Electric Motors: Theory, Design and Practical Application", Prentice Hall Inc., New Jersey,1987
5. Floyd E Saner,"Servo Motor Applications", Pittman USA, 1993.
6. Kenjo, T and Naganori, S "Permanent Magnet and brushless DC motors", Clarendon Press, Oxford, 1989.
7. Generalized Theory of Electrical Machines – P.S.Bimbra-Khanna publications-5th edition-1995
8. Ghosh Control in Robotics and Automation: Sensor Based Integration, Allied Publishers,Chennai.1998
9. Deb.S.R)- Robotics technology and flexible Automation, John Wiley, USA. 1992
10. Asfahl C.R.)- Robots and manufacturing Automation, John Wiley, USA. 1992
11. Klafter R.D., Chimielewski T.A., Negin M Robotic Engineering – An integrated approach, Prentice Hall of India, New Delhi. 1994
12. Mc Kerrow P.J. Introduction to Robotics, Addison Wesley, USA. 1991

Course Title: Advanced Simulation Laboratory
Paper Code: SPE622

L	T	P	Credits	Marks
0	0	8	4	100

Course Objectives: The major objectives of this course to import the practical knowledge about Fuzzy Logic, Neural Network and PID Controllers using MATLAB software.

List of Experiments

The following experiments may be implemented using MATLAB/SIMULINK environment in Advanced Simulation Laboratory.

1. Construction of Simulink model for single area and multi area Power system.
2. Implementation of Full order and minimum order Observer.
3. Implementation of Back-Propagation Algorithm.
4. Implementation of simple Fuzzy controller.
5. Implementation of storage and recall algorithm of Hopfield network model.
6. Implementation of Kalman Filter.
7. Implementation of Least squares error method.
8. Implementation of PID controller and its effects on a given system.
9. Design of Lead, Lag, Lead- Lag compensators using frequency domain analysis.
10. Construction of Simulink model for an Induction motor.
11. Solving steady state Ricatti Equation.
12. Solving an optimal control problem using Ricatti equation.
13. To implement fuzzy set operations
14. To implement fuzzy relational operations.
15. To design and implement fuzzy temperature controller
16. To design and implement Fuzzy Traffic light controller
17. To write and illustrate the concept of Fuzzy C – means Clustering
18. To design a self executable fuzzy logic controller
19. Write programs to test the learning rules of Hebb, Perceptron, Delta, and Widrow Hoff in MATLAB learning rule.
20. To implement the Back propagation algorithm
21. To write and test a program for the linear separability of the input domain
22. To write and implement a Hopfield algorithm.
23. To write a program for pattern recognition
24. To design a self executable neural classifier.
25. Implementation of Preliminary Transformations:
    (a) Transfer function to State space models vice- versa.
    (b) Conversion of Continuous to Discrete time systems vice-versa.
    (c) Verification of controllability and observability of a given system.

Course Title: Research Seminar
Paper Code: SPE623

L	T	P	Credits	Marks
0	0	8	4	100

Course Objectives: To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his ideas and thus creating in him self esteem and courage that are essential for an engineer.

Individual students are required to choose a topic of their interest from energy related engineering topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 30 minutes followed by a 10 minutes session for discussion/question and answers. A committee consisting of at least three faculty members (preferably specialized in Solar Power Engineering) shall assess the presentation of the seminar and award marks to the students. Each
student shall submit two copies of a write up of his / her seminar topic. One copy shall be returned to the student after duly certifying it by the Chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Note: (i) The seminar topic selected by the student must be approved by the authorized faculty of the department at least two weeks in advance.
(ii) Each student has to submit to the department a seminar report at least three days before the day of seminar.
(iii) Each student has to make the Power Point presentation with multi-media projector.

Course Title: Dissertation-I
Paper Code: SPE624

L	T	P	Credits	Marks
0	0	8	4	100

Course Objectives: To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The dissertation work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.

The dissertation work can be a design project / experimental project and or computer simulation project on engineering or any of the topics related with Solar Power Engineering. The dissertation work is allotted individually on different topics. The students shall be encouraged to do their dissertation work in the parent institute itself. If found essential, they may be permitted to continue their dissertation work outside the parent institute as per regulations of M.Tech of DAV University, Jalandhar. Department will constitute an Evaluation Committee to review the dissertation work. The Evaluation committee consists of at least three faculty members of which internal supervisor and another expert in the specified area of the project shall be two essential members. The student is required to undertake the Dissertation-I during the third semester and the same is continued in the 4^{th} semester.(Dissertation-II).

Dissertation-I consists of preliminary thesis/dissertation work, two reviews of the work and the submission of preliminary report. First review would highlight the topic, objectives, methodology and expected results. Second review evaluates the progress of the work, preliminary report and scope of the work, which is to be completed in the 4^{th} semester.

Course Title: Dissertation-II
Paper Code: SPE625

L	T	P	Credits	Marks
0	0	48	24	600

Course Objectives: To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The dissertation work-II aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.

Dissertation-II is a continuation of Dissertation-I started in the 3rd semester of M.Tech. Before the end of the 4th semester, there will be two reviews, one at middle of the fourth semester and other towards the end. In the first review, progress of the Dissertation work done is to be assessed. In the second review, the complete assessment (quality, quantum and authenticity) of the Dissertation is to be evaluated. Both the reviews should be conducted by supervisor and Evaluation committee. This would be a pre qualifying exercise for the students for getting approval for the submission of the Dissertation. At least two research papers are to be prepared for possible publication in Referred Journal/Science Index Journals having impact factor more than 1.
The research papers are to be submitted along with the dissertation. The final evaluation of the project will be external evaluation

Course Title: Advanced Thermodynamics
Paper Code: SPE651

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: The major objectives of this course to educate students about advanced thermodynamics and their applications in Solar Power Engineering

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 60 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Equation of State: State postulate for Simple System and equation of state, Ideal gas equation, Deviation from ideal gas, Equation of state for real gases, generalized Compressibility chart, Law of corresponding states, Properties of Pure Substance: Phase change process of pure substances, PVT surface, P-v &P- T diagrams, Use of steam tables and charts.

Unit-B: Laws of thermodynamics, 2nd law Analysis for Engg. Systems, Entropy flow & entropy generation, Increase of entropy principle, entropy change of pure sub, T-ds relations, entropy generation, thermo electricity, Onsager equation. Exergy analysis of thermal systems, decrease of Exergy principle and Exergy destruction , Thermodynamic Property Relations, Partial Differentials, Maxwell relations, Clapeyron equation, general relations for du, dh, ds, and Cv and Cp, Joule Thomson Coefficient, Δh, Δu, Δs of real gases.

Unit-C: Chemical Thermodynamics:Chemical reaction - Fuels and combustion, Enthalpy of formation and enthalpy of combustion, First law analysis of reacting systems, adiabatic flame temperature, Chemical and Phase equilibrium - Criterion for chemical equilibrium, equilibrium constant for ideal gas mixtures, some remarks about Kp of Ideal-gas mixtures, fugacity and activity, Simultaneous relations, Variation of Kp with Temperature, Phase equilibrium, Gibb's phase rule, Third law of thermodynamics, Nerst heat theorem and heat death of universe

Unit-D: Gas Mixtures – Mass & mole fractions, Dalton's law of partial pressure, Amagat's law, Kay's rule. Statistical Thermodynamics- Fundamentals, equilibrium distribution, Significance of Lagrangian multipliers, Partition function for Canonical Ensemble, partition function for an ideal monatomic gas, equipartition of energy, Bose Einstein statistics, Fermi-Dirac statistics,

Suggested Books:

1. Cengel, Thermodynamics, TMH
2. Howell & Dedcius: Fundamentals of engineering Thermodynamics, McGraw Hill, Inc, USA
3. Van Wylen & Sontag: thermodynamics, John Wiley & Sons, Inc.,USA
4. Holman, Thermodynamics, 4th edition, McGraw Hill
5. Zimmansky & Dittman, Heat and Thermodynamics, 7th edition, TMH
6. Rao, Y.V.C., Postulational and Stastistical thermodynamics, Allied Pub. Inc.
7. Jones and Hawkings: engineering Thermodynamics, john Wiley & Sons, Inc. USA
8. Faires V. M. and Simmag: Thermodynamics. McMillan Pub. Co. Inc. USA
9. Turns, Thermodynamics- Concepts and Applications, Cambridge University Press
10. Wark, Advanced Thermodynamics, McGraw Hill
11. Nag P.K., Basic & Applied Thermodynamics, TMH, New Delhi.
12. Jones & Dugan, Advanced Thermodynamics, Prentice Hall Int.
13. Bejan, Advanced Thermodynamics, John Wiley, Inc.

Course Title: Energy Conversion Systems
Paper Code: SPE652

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: To understand the principles and operations related to Energy Conversion Systems.

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Classification of energy sources - Utilization, economics and growth rates - Fossil fuels, nuclear fuels and solar energy - Combustion calculations - Conventional thermal power plant design and operation - Superheat, reheat and regeneration - Other auxiliaries of thermal plant - High-pressure boilers - Steam generator control

Unit-B: Gas turbine and combined cycle analysis – Inter-cooling, reheating and regeneration-gas turbine cooling –design for high temperature - Combined cycles with heat recovery boiler – Combined cycles with multi-pressure steam - STAG combined cycle power plant - Influence of component efficiencies on cycle performance.

Unit-C: Solar energy – The Sun – Production and transfer of solar energy — Solar thermal collectors –General description and characteristics –Solar concentrators –Energy from biomass – Sources of biomass – Different species – Conversion of biomass into fuels – Energy through fermentation – Pyrolysis, gasification and combustion – Aerobic and anaerobic bio-conversion –Properties of biomass .Wind energy – Principles of wind energy conversion – Site selection considerations –Wind power plant design –Types of wind power conversion systems– Operation, maintenance and economics – Geothermal energy – Availability, system development and limitations – Ocean thermal energy conversion – Wave and tidal energy –Scope and economics – Introduction to integrated energy systems.

Unit-D: Energy efficiency - Energy accounting, monitoring and control – Thermal and Electricity audit instruments-Energy consumption models - Specific Energy Consumption – ECO assessment and Evaluation methods – Transformer loading/efficiency analysis – Feeder loss evaluation - Lighting - Energy efficient light sources Domestic/commercial industrial lighting- Lighting controls - Energy conservation in lighting schemes Luminaries - Case studies.

Suggested Books:

1. El-Wakil M. M., Power Plant Technology, McGraw Hill, 1985
2. Culp Jr A. W., Principles of Energy Conversion, McGraw Hill, 2001
3. Sorensen ,H. A., Energy Conversion Systems, J. Wiley, 1983
4. Morse, T. F., Power Plant Engineering, Affiliated East West Press, 1978
5. Saigh, A.A.M., (Ed): Solar Energy Engineering, Academic Press, 1977
6. Kreith, F., and J.F. Kreider, Principles of Solar Engineering, McGraw Hill, 1978
7. Mittal , K.M.,Non-conventional Energy Systems - Principles, Progress and Prospects, Wheeler Publications, 1997.
8. Turner, W.C., Energy Management Handbook, 2e, Fairmont Press, 1993.

Course Title: Soft Computing Techniques
Paper Code: SPE653

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: To understand the principles of neural networks, fuzzy logic and genetic algorithms and its Engineering application.

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Artificial Intelligent systems–Neural Networks, Fuzzy Logic and Evolutionary Programming concepts. Artificial Neural Networks – Biological neural networks – Model of an artificial neuron – Comparison between biological neuron and artificial neuron – Basic models of artificial neural networks – Learning methods –Activation function and terminologies of ANN – McCulloch Pitts Neuron – Linear Separability – Hebb network– Perceptron Networks, Adaline, Madaline.

Unit-B: Back propagation Networks: Architecture – Multi layer perceptron – Back propagation learning – Input layer, Hidden Layer, Output Layer computations, Calculation of error, Training of ANN, Back propagation Algorithm, Momentum and Learning rate, Selection of various parameters in BP networks – Radial Basis Function Networks. Variations in standard BP algorithms – Decremental iteration procedure, Adaptive BP, GA based BP, Quick prop training, Augmented BP networks, Sequential learning Approach for single hidden layer Neural networks.

Unit-C: Fuzzy sets and crisp sets-Fuzzy sets – Fuzzy set operations-Fuzzy relations – Membership functions – Features of the membership function – Methods of membership value assignment – Defuzzification – Defuzzification methods – Fuzzy Rule Base and approximate reasoning – Truth values and tables in fuzzy logic, Fuzzy propositions, Formation of rules, Decomposition of rules, Aggregation of fuzzy rules – Fuzzy Inference Systems – Construction and Working Principle of FIS – Methods of FIS – Mamdani FIS and Sugeno FIS – Fuzzy Logic Control Systems – Architecture and Operation of FLC System – FLC System Models – Application of FLC Systems.

Unit-D: Genetic Algorithms – Basic Concepts – Creation of off-springs – Working Principle – Encoding – Fitness function – Reproduction – Roulette – Wheel Selection, Boltzmann Selection – Tournament selection – Rank Selection – Steady – State Selection – Elitism – Generation gap and steady state replacement – Inheritance operators – Cross Over-Inversion

and deletion – Mutation operator – Bit – wise operators – Generational Cycle – convergence of Genetic Algorithm – Differences and Similarities between GA and other traditional methods – Applications.

Suggested Books:

1. S. N. Sivanandam, S. N. Deepa, Principles of Soft Computing, Wiley India Pvt. Ltd [Module I & III]
2. R. Rajasekharan and G.A. Vijayalakshmi Pai, Nerural Networks, Fuzzy Logic and Genetic algorithms-Synthesis and Applications, Prentice Hall of India. [Module II&IV]
3. Fakhreddine O. Karray, Clarence De Silva, Intelligent Systems Design, Theory, Tools and Application, Pearson Education.
4. S. Haykins, Neural Networks – A Comprehensive foundation, Prentice Hall 2002.
5. L. Fausett, Fundamentals of Neural Networks, Prentice Hall 1994.
6. T. Ross, Fuzzy Logic with Engineering Applications, Tata McGraw Hill, New Delhi 1995.
7. D. E. Goldberg, Genetic Algorithms in search, Optimization and machine Learning, Addison Wesley MA, 1989.

Course Title: Design of Equipments For Energy Conversion Systems
Paper Code: SPE654

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: To provide a basic knowledge for designing equipment related energy conversion systems.

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Factors influencing the design of pressure vessels, design criterion of elliptical, hemispherical, conical, toriconical and torispherical heads, Stresses in pressure vessels, Autofrettage, Thermal stresses, Design of pressure vessel components such as shell, heads, Nozzles, Flanges as per ASME & IS codes.

Unit-B: Design of vessels, Buckling, Buckling phenomenon, Elastic buckling of circular ring and cylinders under external pressure, Stiffeners. Piping, Flexibility analysis, Design as per ANSI Codes.

Unit-C: Heat exchangers, classification, selection, heat transfer and flow friction characteristics, pressure drop analysis, basic thermal design, theory of heat exchangers, E-NTU, P-NTU and MTD method , F-factor for various configurations , applications to design, Shell and tube heat exchanger, construction and thermal features, thermal design procedure, Kern method, Bell Delaware method.

Unit-D: Thermal design of regenerators, classifications, governing equations, design parameters, Design of compact heat exchangers, plate and fin, fin-tube and plate and frame heat exchangers, fouling and corrosion in heat exchanger.

Suggested Books:

1. J. F. Harvey, Theory and Design of Pressure Vessels, CBS Publishers and Distributors, 1987.
2. Henry H. Bedner, Pressure Vessels, Design Hand Book , CBS Publishers and Distributors, 1987.
3. Stanley, M. Wales, Chemical Process Equipment, Selection and Design, Buterworths series in Chemical Engineering, 1988.
4. ASME Pressure Vessel Codes Section VIII, 1998.
5. Dennis Moss Pressure vessel design manual Gulf publishing, 2003
6. Brownell, L. E., and Young, E. H., Process Equipment Design, John Wiley and Sons
7. Kern, D. Q., Process Heat Transfer, Tata McGraw-Hill, 2000.
8. Fraas, A. P., Heat Exchanger Design, Second Edition, John Wiley & Sons, 1989
9. Das, S.K., Prosess heat transfer, Narosa publishing house, 2005.

Course Title: Materials Science And Tribology For Energy Conversion Systems
Paper Code: SPE655

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: To understand the principles of behavior of ductile and brittle materials and lubrication systems

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Elastic behaviour of materials and composites, plastic deformation, slip systems in crystals, strengthening, ductile and brittle fracture, Griffith Criterion, Creep and Fatigue. Factors influencing functional life of components at elevated temperatures, definition of creep curve, various stages of creep, metallurgical factors influencing various stages, effect of stress, temperature and strain rate. Design of transient creep time, hardening, strain hardening, expressions of rupture life of creep in ductile and brittle materials, Monkman-Grant relationship.

Unit-B: Corrosion: Corrosion theory and mechanisms, in depth corrosion chemistry for boilers, pipelines, cooling towers and pressure vessels, Oxidation, Pitting, Bedworth ratio, kinetic laws of oxidation- defect structure and control of oxidation by alloy additions, hot gas corrosion deposit, modified hot gas corrosion, fluxing mechanisms, effect of alloying elements on hot corrosion, interaction of hot corrosion and creep, methods to combat hot corrosion.

Unit-C: Engine Lubrication System and their components, bearing lubrication, lubrication of piston, ring and liners, function of engine lubrication, fundamental of lubrication, regimes of lubrication-hydrodynamic, mixed and boundary lubrication, elasto- hydrodynamic lubrication, description of engine components working of each of these regimes . Lubricants – Selection criteria.

Unit-D: Surfaces features – Topography- Experimental Determinations of surface structure – Chemical analysis of surface – Surface effects in Tribology –Friction – Mechanism of friction, measuring friction, Properties of metallic and non metalli c materials- friction in extreme conditions - Wear – Types, mechanism, mapping, measurements, wear resistance materials – surface treatment, surface modifications and surface coatings

Suggested Books:

1. Raj. R., "Flow and Fracture at Elevated Temperatures, American Society for Metals, USA, 1985.
2. Hertzberg R. W., "Deformation and Fracture Mechanics of Engineering materials,4th Edition, John Wiley, USA, 1996.
3. Courtney T.H, "Mechanical Behavior of Materials, McGraw-Hill, USA, 1990.
4. Halling, J.(Editor) – " Principles of Tribology", MacMillan, 1984.
5. Williams, J.A. "Engineering Tribology", Oxford University Press, 1994.

Course Title: Optimization Techniques
Paper Code: SPE656

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: To impart knowledge on various aspects of optimization techniques

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Mathematical preliminaries: Mathematical programming problems-varieties and characteristics-Examples of problem formulation, difficulties caused by non- linearity, Convex sets-convex functions, concave functions, convex feasible region optimal solution, Quasi- convexity, unimodal function, Differentional functions gradient and Hessian, properties of convex functions.

Unit-B: Unrestricted and classical optimization: search methods- Fibonacci search, Golden section search, Quadratic interpolation method, pattern search method, steepest descent method, Quasi Newton method, Hooke and Jeeves method, Lagrangier Multiplier method, Sufficiency condition, calculus of variations, Euler's equation, Necessary condition, transversality condition, problems with constraints

Unit-C: Constrained non-linear optimization: problems involving inequality constraints, Kuhn-Tucker conditions Quadratic programming, Wolfe's method- method of feasible directions, Frank and Wolf method, Convex simplex method, separable programming, Kelly's cutting plane method-Penalty and Barier methods

Unit-D: Integer and dynamic programming, Optimization methods applied to unconstrained and constrained linear and non-linear functions of one or more variables, Introduction to response surface methods and genetic algorithms, Non-linear function approximation using neural networks in optimization, Biological methods in optimization.

Suggested Books:

1. Kambo N.S, Mathematical programming techniques, Affiliated East West, 1984.
2. Intriligantor M.D., Mathematical Optimization and Economic theory, Prentice Hall,1971.
3. Rao S.S., Optimization theory and applications,Wiley Eastern 1978.
4. Summons,D.L., Non-linear programming for operations research, prentice hall 1975.
5. Ranjan Ganguli., Engineering Optimization–A Modern Approach, Universities Press, Hyderabad, 2011.

Course Title: Advanced Solar Engineering
Paper Code: SPE657

L	T	P	Credits	Marks
4	0	0	4	100

Objectives: To understand the basics of solar engineering, its collection and its applications.

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Sun and it's Energy: Solar spectrum, solar constant & solar radiations, Sun earth angles, solar hourly radiations-Radiations on Horizontal and inclined surfaces. Measurement of Solar Radiation: Pyrheliometer, Pyranometer, Sunshine-Recorder.

Unit-B: Collection of Solar Energy: Flat plate collectors, classification, construction, heat transfer coefficients, optimisation of heat losses - Analysis of flat plate collectors, testing of collectors-Solar Air Heater : Description & classification, conventional air heater, air heater above the collector surface air heaters with flow on both sides of absorbers to pan air heater, air heater with finned absorbers, porous absorber.

Unit-C: Solar Water heater: Collection cum storage water heater, Natural circulation & forced circulation water heater, shallow solar ponds. Solar Concentrators: Classification, characteristic parameters, types of concentrators materials in concentrators.

Unit-D: Passive Solar House: Thermal gain, Thermal cooling, Ventilation. Energy Storage: Sensible heat storage, Liquid, Solid, packed bed, Latent heat storage. Solar Distillation, Solar Cookers, Solar Refrigeration.

Suggested Books:

1. Tiwari, G.N. and Sayesta Suneja., "Solar Thermal engineering Systems", Narosa Publishing House.
2. Duffie and Backuran, Solar Thermal Engineering.
3. Sukhatme, "Solar Engineering".
4. H.P. Gupta., "Solar Engineering"

Course Title: Nuclear Engineering
Paper Code: SPE658

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: To provide knowledge on various aspects of nuclear engineering.

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Nuclear model of the atom, Equivalence of mass and energy, Binding, Radio activity, Half life, Neutron interactions, Cross sections

Unit-B: Mechanism of nuclear fission and fusion, Radio activity, Chain reactions, Critical mass and composition, Nuclear fuel cycles and its characteristics, Uranium production and purification, Zirconium, thorium, beryllium

Unit-C: Nuclear fuel cycles, spent fuel characteristics, Role of solvent extraction in reprocessing, Solvent extraction equipment, Reactors, Types of reactors, Design and construction of fast breeding reactors, heat transfer techniques in nuclear reactors, reactor shielding.

Unit-D: Nuclear plant safety- Safety systems - Changes and consequences of an accident - Criteria for safety – Nuclear waste - Type of waste and its disposal - Radiation hazards and their prevention - Weapons proliferation.

Suggested Books:

1. Thomas J. Cannoly, “Fundamentals of Nuclear Engineering ", John Wiley, 1978.
2. Collier J.G., and G.F.Hewitt, “Introduction to Nuclear Power ", (1987), Hemisphere Publishing, New York, 1987
3. Lamarsh U.R. " Introduction to Nuclear Engineering Second Edition ", (1983), Addison Wesley M.A., 1983.
4. Lipschutz R.D., "Radioactive Waste - Politics, Technology and Risk ", Ballingor, Cambridge. M.A. ,1980

Course Title: Nano Science and Technology
Paper Code: SPE659

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: To understand the concept of nanotechnology, nanomaterials, characterization of nano particles and emerging application of nanomaterials.

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Introduction - What is nano? Why nano? Nanomaterials, Solid state Physics: Crystal structure, crystal diffraction and reciprocal lattice, point groups and space groups.

Unit-B: Types of bonding-elementary ideas about point defects and dislocations, lattice vibrations, phonons, specific heat of solids, free electron theory, Fermi statistics- heat capacity.

Unit-C: Nanomaterials, Fabrication and characterization: Bottom-up vs. top-down, Epitaxial growth, principles of Self-assembly, Characterization : XRD, TEM, SEM, STM, AFM , XPS.

Unit-D: Electronic Nanodevices, Magnetic Nanodevices, Photonic Nanodevices, Semiconductor quantum dots, Photonic crystals, Metamaterials, Societal, Health and Environmental Impacts.

Suggested Books:

1. Kulkarni, S.K., Nanotechnology: Principles and Practices, Capital Publishing Co., 2007.
2. Kelsall, R., Hamley, I., and Geoghegan, M. (Eds), Nanoscale Science and Technology,Wiley, 2005.
3. Hummel, R.E., Electronic Properties of Materials, Third Edn, Springer, 2001.

Course Title: Energy Conservation & Heat Recovery Systems
Paper Code: SPE660

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: To understand various methods of energy conservation & heat recovery systems

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Energy consumption and potential for energy conservation in industry-thermodynamics of energy conservation energy, flows-energy auditing-technologies for energy conservation-thermal insulation. waste heat recovery systems, thermal energy storage, heat exchanger, heat pumps, heat pipes, waste heat to mechanical energy, conversion systems, design for conversion of energy, Applications and case studies.

Unit-B: Definition of energy management, Energy conservation schemes, Optimizing steam usage, Waste heat management, Insulation, Optimum selection of pipe size, Energy conservation in space conditioning, Energy and cost indices, Energy diagrams, Energy auditing, Thermodynamic availability analysis, Thermodynamic efficiencies, Available energy and fuel.

Unit-C: Thermodynamic analysis of common unit operations - Heat exchange - Expansion - Pressure let down - Mixing- Distillation - Combustion air pre-heating – Systematic design methods - Process synthesis - Application to cogeneration system – Thermo-economics - Systematic optimization - Improving process operations – Chemical reactions - Separation - Heat transfer - Process machinery - System interaction and economics

Unit-D: Potential for waste heat recovery - Direct utilization of waste heat boilers – Use of heat pumps – Improving boiler efficiency - Industrial boiler inventory – Use of fluidized beds - Potential for energy conservation – Power economics - General economic problems – Load curves - Selections of plants - Specific economic energy problems - Energy rates.

Suggested Books:

1. Kenney W F- Energy conservation in the Process industries
2. Chiogioji M H- Industrial energy conservation
3. Bernhardt G A. Sjritsju & Vopat W A – Power station engineering & economy
4. Thumann, Albert PE- Plant Engineers and Managers Guide Energy Conservation
5. Dubin F B-Energy conservation standards
6. A.P.E. Thummann: Fundamentals of Energy Engineering, Prentice Hall, 1984
7. M.H. Chiogioji: Industrial Energy Conservation, Marcel Dekker, 1979
8. W. R. Murphy and G. McKay: Energy Management, Butterworth-Heinemann, 2001

Course Title: Energy Modeling, Economics and Management
Paper Code: SPE661

L	T	P	Credits	Marks
4	0	0	4	100

Course Objectives: To understand the concepts of energy demand forecasting and management of projects

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Models and modeling approaches: Input output analysis, energy demand analysis and forecasting, economics of stand alone power supply systems, project management. Macroeconomic Concepts, Measurement of National Output-Investment Planning and Pricing, Economics of Energy Sources, Reserves and Cost Estimation, Multiplier Analysis, Energy and Environmental Input / Output Analysis-Energy Aggregation-Econometric Energy Demand Modeling-Overview of Econometric Methods. Methodology for Energy Demand Analysis , Methodology for Energy Technology Forecasting-Methodology for Energy Forecasting, Sectoral Energy Demand Forecasting, Solar Energy Biomass Energy, Wind Energy and other Renewable Sources of Energy , Economics of Waste Heat Recovery and Cogeneration, Energy Conservation Economics, Cost Analysis, Budgetary Control Financial Management, Techniques for Project Evaluation.

Unit-B: Basic concept of econometrics and statistical analysis: The 2-variable regression model, The multiple regression model; Tests of regression coefficients and regression equation, Econometric techniques used for energy analysis and forecasting with case studies form India, Operation of computer package Input – Output Analysis, Basic concept of Input-output analysis, concept of energy multiplier and implication of energy multiplier for analysis of regional and national energy policy; Energy and environmental Input – Output analyses using I-O model.

Unit-C: Energy Modeling: Interdependence of energy-economy-environment, Modeling concept, and application, Methodology of energy demand analysis; Methodology for energy forecasting, Sectoral energy demand forecasting, Interfuel substitution models, SIMA model, and I-O model for energy policy analysis, Simulation and forecasting of future energy demand consistent with macroeconomic parameters in India; Energy

Economics and Policies: National and Sectoral energy planning, Integrated resources planning, Energy pricing.

Unit-D: Project Evaluation & Management: Financial analysis: Project cash flows, time value of money, life cycle approach & analysis, conception, definition, planning, feasibility and analysis, Project appraisal criteria; Risk analysis; Project planning matrix; Aims oriented project planning; Social cost benefit analysis. Network analysis for project management, Time estimation; Critical path determination, PERT, CPM and CERT: Fuzzy logic analysis, Stochastic based formulations; Project evaluation techniques, Funds planning, Project material management, evaluation & analysis, Implementation and monitoring; Performance indices, Case studies.

Suggested Books:

1. Energy Policy Analysis and Modeling, M. Munasinghe and P. Meier Cambridge University Press, 1993.
2. The Economics of Energy Demand: A Survey of Applications, W.A Donnelly New York, 1987.
3. Econometrics Models and Economic Forecasts, S. Pindyck and Daniel L Rubinfeld, 3rd edition McGraw Hill, New York, 1991.
4. Sectoral Energy Demand Studies: Application of the END-USE Approach to Asian Countries, UN-ESCAP, New York 1991.
5. Guide Book on Energy – Environment Planning in Developing Countries – Methodological Guide on Economic Sustainability and Environmental Betterment Through Energy Savings and Fuel Switching in Developing Countries, UN-ESCAP, New York 1996.
6. Forecasting Methods and Applications, S.Makridakis, Wiley 1983.

Course Title: Solar Energy Systems
Paper Code: SPE662

L	T	P	Credits	Marks
4	0	0	4	100

Course objectives: The objective of this course is intended to educate students in the design and applications of solar energy technology. It will focus on fundamentals of solar energy conversion, solar cells, optical engineering, photoelectrochemical cells, thermoelectric generators, and energy storage and distribution systems. The course covers solar energy insolation and global energy needs, current trends in photovoltaic energy engineering, solar cell material science, design and installation of solar panels for residential and industrial applications and connections to the national grid and cost analysis of the overall system. In addition, basic manufacturing processes for the production of solar panels, environmental impacts, and the related system engineering aspects will be included to provide a comprehensive state-of-the art approach to solar energy utilization.

NOTE:

- The question paper for end-semester examination will have a weightage of 25%. It will consist of 100 objective questions. All questions will be compulsory.
- Two preannounced test will be conducted having a weightage of 25% each. Each preannounced test will consist of 20 objective type, 5 short answer type questions and one long answer type question. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt all question. Choice will be given only in long answer type. The question paper is expected to contain problems to the extent of 40% of total marks.
- Four objective/MCQ type surprise test will be taken. Two best out of Four objective/MCQ type surprise test will be considered towards final, each of 12.5% weightage to the final. Each surprise test will include 20-25 questions.
- The books indicated as text-book(s) are suggestive. However, any other book may be followed.

Unit-A: Solar energy conversion: Photovoltaic, Photoelectrochemical, Photothermal, and Thermoelectric systems: Solar energy: solar insolation vs. world energy demand, current energy consumption from different sources, environmental and health effects; Sustainable Energy: production and storage, resources and utilization.
Thermoelectric systems: Thermoelectricity, Peltier effect, Seebeck effect; Thermoelectric materials, Bismuth telluride, automotive thermoelectric generators, radioisotope, thermoelectric generator; Thermoelectric power generators, thermoelectric refrigerators and heat pumps.

Unit-B: Photovoltaics (PV): 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 heterojunctions, and semiconducting materials for solar cells.

Unit-C: Cost analysis and environmental issues: Cost analysis and pay back calculations for different types of solar panels and collectors, installation and operating costs; Environmental and safety issues, protection systems, performance monitoring.

Unit-D: Thin film solar cells: Single crystal, polycrystalline and amorphous silicon solar cells, cadmium telluride thin-film solar cells, conversion efficiency; Current trends in photovoltaic research and applications; nanotechnology applications, quantum dots, solution based processes solar cell production.

Suggested Books:

1. Principles of Solar Engineering, D. Yogi Goswami, Taylor and Francis, 2000, ISBN 10: 1-56032-714-6
2. Applied Photovoltaics, Stuart Wenham, Martin Green, and Muriel Watt, Earthscan, 2007, ISBN 1-84407-407-3
3. Photovoltaic Engineering Handbook, F. Lasnier and T. G. Ang, IOP Publishing UK (Adam Hilger USA) 1990, ISBN 0-85274-311-4
4. Semiconductor Devices, Physics, and Technology, Second Edition, S. M., Sze, New York, NY: Wiley, 2001. ISBN: 0471874248.