JAMIA MILLIA ISLAMIA
(A Central University by an Act of Parliament)

Department of Physics
Faculty of Natural Sciences

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The Minutes of the Meeting of Board of Studies held on 07.05.2018 at 11.00 A.M.

A meeting of the Board of Studies (BoS) of the Department of Physics was held on 7th May, 2018 at 11.00 AM. The following members were present:

Prof. Saeeduddin (Chair)
Prof. P.K. Bhatnagar (External member)
Prof. Zishan H. Khan (Department of Applied Science & Humanities)
Prof. M. Zulfequar
Dr. Asad Niazi
Dr. Azher Majid Siddiqui
Dr. Mohd. Shahid Khan
Dr. Anver Aziz
Dr. Arun Singh
Mr. Pumlian Monga
Dr. Somasri Sen
Dr. Javid Ali
Dr. Raza Shahid

1. The minutes of the last meeting of BoS held on 23/03/2018 were confirmed.
2. The changes in the Course structure of M.Sc. Physics as appended below were approved.

M.Sc. Physics (Semester - I) :

S.No.	Title of Paper	Paper type	Paper Code	Credit	Maximum Marks (Internal Assessment)	Maximum Marks (University Exam.)
	Quantum Mechanics - I	Core	PHM-11C	4	25	75
2.	Mathematical Physics - I	Core	PHM-12C	4	25	75
3.	Classical Mechanics	Core	PHM-13C	4	25	75
4.	Electronics (Choice Based Elective)	CBCS	PHM-11E	4	25	75
5.	Lab I	Lab.	PHM-11L	6	75	75

3	Particle Physics	Core	**PHM 43CT**	4	25	75
4	Project	Project	**PHM 44C**	6	75	75
	Electives					
1	Physics of Novel Materials	CBCS	**PHM 41E**	4	25	75
2	Laser Spectroscopy	CBCS	**PHM 42E**	4	25	75
3	Quantum Field Theory	CBCS	**PHM 43E**	4	25	75

3. The distribution of theory courses for M.Sc. (Physics) and B.Sc. (H/P/S) for odd semesters for the Session 2018-2019 was approved.

4. The introduction of B.Voc. (Solar Energy) in Self Financing mode from the Academic Session 2018-2019 was also approved.

The meeting ended at 12.30 P.M. with thanks to the Chair.

(Dr. Saeed Uddin)
Professor & Head

Professor & Head
Department of Physics
Jamia Millia Islamia
New Delhi-110025

JAMIA MILLIA ISLAMIA
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Maulana Mohammad Ali Jauhar Marg, New Delhi-110025
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(संसदीय अधिनियमानुसार केन्द्रीय विश्वविद्यालय)
मौलाना मोहम्मद अली जौहर मार्ग, नई दिल्ली–110025

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Office of the Registrar कुलसचिव कार्यालय دفتر مُسَجِّل

AC-9(2)/RO/2018

24 October 2018

NOTIFICATION

The Shaikh-ul-Jamia (Vice-Chancellor), JMI, in anticipation of the approval of Majlis-i-Talimi (Academic Council), is pleased to grant permission to start admission for "B. Voc. Solar Energy" (Self-finananced) program in Department of Physics, JMI from the current academic session 2018-19.

(A.P. Siddiqui), IPS
Registrar

To::

1. All Deans of Faculties/HoDs/Directors of Centres, JMI
2. The Head, Deptt. of Physics, JMI
3. The Dy. Finance Officer, JMI
4. The Controller of Exams., JMI — (With a request to start online process of application forms.)
5. The Media Coordinator, JMI for press release.
6. The Asstt. Registrar (A&C) for placing before the Academic Council, JMI

Copy to:

1. The Secretary to Vice-Chancellor, JMI
2. The Asstt. Registrar, Registrar's Secretariat, JMI

डॉ. के. पी. सिंह
संयुक्त सचिव
Dr. K.P. Singh
Joint Secretary

27809
01/07/15

University Grants Commission
(मानव संसाधन विकास मंत्रालय, भारत सरकार)
(Ministry of Human Resource Development, Govt. of India)
बहादुरशाह ज़फ़र मार्ग, नई दिल्ली-110002
Bahadur Shah Zafar Marg, New Delhi-110002
दूरभाष Phone : कार्यालय Off : 011-23239597
फैक्स Fax : 011-2323 6347, e-mail: kpsingh.ugc@nic.in

By Speed Post

D.O.No.F.2-7/2015(B.Voc)

June, 2015

Dear Sir/Madam,

Kindly refer to the proposal of your university for starting courses under the scheme of Community Colleges from the academic session 2015-16. In this connection, this is to inform you that the UGC has approved your proposal for starting course under the scheme of Community College in the specialization and as per the intake given below

Specialization/Trade	Intake
B Voc in Solar Energy	50

Further, UGC has ~~also~~ approved a grant of Rs. 90.00 (Ninty Lakhs Only) to the university for a period of two years for running the course as per the details given below

Sl. No.	Budget Head	Amount (Rupees in lakhs)
	Grant-in-aid General – 35 (Non-recurring)	
i	Setting up of Lab/Workshop facilities/ procurement of teaching and Learning Material, Machinery/equipments	25.00
	Total	**25.00**
	Grant-in-aid General – 31 (Recurring)	
ii	Faculty-1 (Asst. Professor on contract)	25.00
iii	Visiting/Guest Faculty	25.00
iv	Operative Cost	15.00
	Total	65.00

Grant Total (3 Years)= Rs. 25.00 Lakhs (NR) + Rs. 65.00 (R) = Rs. 90.00 (Ninty Lakhs Only)

This approval is subject to the terms and conditions and other provisions as laid down in the guidelines available on UGC website. Separate allocation is being made alongwith the XII plan General Development Assistance to implement the scheme which will be communicated to you shortly. Expenditure may be made as indicated in this approval letter, out the earmarked grant for the scheme. In the meanwhile, you are requested to proceed further towards starting of the course from the academic session 2015-16 itself. A copy of the Report of the Expert Committee is also enclosed for your perusal and record. Observations/suggestions of the Committee may please be kept in mind while implementing the programme

Prof. Saeeduddin
Pl. do the needful
Jt. Reg.
2/7/2015

cc: Principal, Polytechnic

Redirected to The Head,
Deptt. of Physics
J.M.I.
2/7/2015

In case of any query, you may get in touch with Dr. Nikhil Kumar, Education Officer (Ph. No 011-23218120 – e.mail: nikhil.ugc@nic.in)

With kind regards and best wishes,

Yours sincer

(K.P Sing

The Registrar,
Jamia Millai Islamia,
Maulana Mohammad Ali Jauhar Marg,
Jamia Nagar-110025,
New Delhi

Bachelor of Vocational

in

Solar Energy

Department of Physics

Jamia Millia Islamia

(A Central University)

New Delhi 110025

Structure of Bachelor of Vocational in Solar Energy Course
(Semester System)

Paper Code	SEM-I	Max. Marks	Credits
	General Education Component		
1GT1	Basic Semiconductor Electronics	75	3
1GT2	Heat and Thermodynamics	75	3
1GT3	Numerical Analysis and Methods - I	75	3
1GP4	Electronics Lab.	75	3
	Skill Education Component		
1ST1	Solar Radiation, Thermal Conversion: Design and Installation - I	100	4
1ST2	Solar Photovoltaic Principles, Design, Power Generation Systems and Applications	100	4
1ST3	Semiconductor Devices and Photo Voltaic	100	4
1SP4	Solar-Thermal Training Lab.	150	6
	Total	750	30
	SEM-II		
	General Education Component		
2GT1	Basic Electrical Circuits	75	3
2GT2	Fundamentals of Heat and Mass Transfer	75	3
2GT3	Numerical Analysis and Methods-II	75	3
2GP4	Thermal Lab	75	3
	Skill Education Component		
2ST1	Solar Radiation, Thermal Conversion: Design and Installation - II	100	4
2ST2	Power Generation Systems and Applications	100	4
2ST3	Photonic Devices and Semiconductor Technology	100	4
2SP4	Solar PV Training Lab - I	150	6
Total		750	30
Paper Code	SEM-III	Max. Marks	Credits

	General Education Component		
3GT1	Digital Electronics	75	3
3GT2	Transducers	75	3
3GT3	Differential Equations	75	3
3GP4	Digital Electronics & Transducers Lab.	75	3
	Skill Education Component		
3ST1	Materials for Solar Thermal and Photovoltaic Systems	100	4
3ST2	Power Electronics for Solar Energy Systems	100	4
3ST3	Green and Energy Efficient Building	100	4
3SP4	Solar PV Training Lab-II	150	6
Total		**750**	**30**
Paper Code	**SEM-IV**	**Max. Marks**	**Credits**
	General Education Component		
4GT1	Digital Electronics	75	3
4GT2	Signal Conditioning	75	3
4GT3	Special Functions and Integral Transforms	75	3
4GP4	Signal Conditioning & Operational Amplifier Lab.	75	3
	Skill Education Component		
4ST1	Materials for Solar thermal Systems	100	4
4ST2	Solar Energy Grid Integration	100	4
4ST3	Solar Policy and Industrial Practices	100	4
4SP4	Solar PV Training Lab-III	150	6
	Total	**750**	**30**
Paper Code	**SEM-V**	**Max. Marks**	**Credits**
	General Education Component		
5GT1	Microcontrollers & Microprocessors (Theory)	75	3
5GT2	Industrial Mathematics (Theory)	75	3
5GP3	Microcontroller and Microprocessor Lab. (Practical)	75	3
	Skill Education Component		
5ST1	Advanced Solar Thermal Energy Conversion Systems & Applications (Theory)	100	4

5ST2	Advanced Photovoltaic Solar Energy Systems & Applications (Theory)	100	4
5SP3	A Short Duration "On Job Training" (OJT) on Operation and Maintenance of Solar Thermal & PV Manufacturing Units (Approx. 1 month period)	150	6
5SS4	Seminar Presentation on the Outcome of OJT	100	4
	Total	675	27
Paper Code	SEM-VI	Max. Marks	Credits
	Skill Education Component		
6ST1	Entrepreneurship and Energy Conservation Management (Theory)	100	4
6ST2	Decentralization of Energy Systems (Theory)	100	4
	Project		
6SP1	Project Involving Hands-on Training in Manufacturing and Installation of Photo Voltaic System in a Solar Power Plant	250	10
6SP2	Seminar Presentation on the Outcome of Project	100	4
	Total	550	22

Total Credits: 164

Semester – I

General Education Course Contents

1GT1 - Basic Semiconductor Electronics

Unit 1: Resisters: General Information: Symbol, color code, Types such as Carbon, Metal Film, thin film, Thick film, wire-wound, variable Potentiometers, Logarithmic, Linear multi- turn. Physical Properties: Temperature Dependence (Thermistor), Light Dependent (LDR), voltage dependent (VDR). Technical specification: wattage, working voltage. Diodes: Linear diodes, Zener Diodes, Varactor Diodes, Photo Diodes, Light Emitting Diodes, Optical Isolator.

Unit 2: A.C Fundamentals: (Frequency, Period, Phase concepts), Average and Effective Values, Fm Factor, Phasor Representation, Vector addition/Subtraction, Polar Notation, Complex Phasor Algebra.

Unit 3: Methods of Measurements: Very low and Very High Resistance, Wheatstone Bridge, Its merit. Inductors: General Information: Symbol, type (air core, iron core, ferrite core) choke, frequency response, methods of measurements.

Unit4: Capacitors: General Information: symbol, color code, types (air, paper, electrolytic, mica, tantalum, polystyrene) Fixed and Variable Capacitors. Specification: Power Factor, working voltage, measurement of capacitance. BJT, JFET, MOSFET.

Books:

1. "Basic Electronics" by Bernard Grob
2. "Basic Electrical" by Malvino

1GT2 - Heat and Thermodynamics

Unit 1: Laws of thermodynamics and their applications: Zeroth law of thermodynamics, First law of thermodynamics, internal energy, enthalpy, specific heat, thermodynamic reactions and processes, application of First law, energy analysis of chemical reaction, phase change process, Second law of thermodynamics, Entropy, application of second law.

Unit 2: Conduction, convection and radiation, Concepts of internal energy, entropy, enthalpy and irreversibility, Gas laws, Thermodynamic cycles: theoretical and actual cycles, Heat engines and heat pumps/refrigeration.

Unit 3 : Rankine cycle, internal combustion engines, diesel engines, refrigeration cycle, basics of chemical thermodynamics, Heat and motive power steam engines, the principal of heat engines, steam turbines, power station turbines, steam power plant,

Unit 4 :Transport phenomena and its importance in energy study, thermo□physical properties of materials and its role in conduction heat transfer, Insulation concept and selection of insulation an its practical examples

Books:

1. Dittman R. H. and Zemansky M. W. (2007); Heat and Thermodynamics, Spl. Indian Edition, Tata McGraw Hill.
2. Potter M. and Somerton C. (2009); Thermodynamics for Engineers, Second Edition, McGraw Hill.

1GT3 - Numerical Analysis & Methods - I

Unit 1: Errors in Numerical Calculations**:** Numbers and their Accuracy, Errors and their Computation, Absolute, Relative and Percentage Errors, A General error Formula, Error in Series Approximation.

Unit 2: Solution of Algebraic and Transcendental Equations**:** Iterative Methods - The Bisection Method, The Method of False Position (Regula Falsi Method), Fixed-Point Iteration Method, Newton Raphson Method, Generalized Newton's Method, Ramanujan's Method, Muller's Method; Acceleration of Convergence – Aitken's Method, Graeffe's Root Squaring Method, Complex roots.

Unit 3: Matrices: Matrix Operations: Addition, subtraction and Multiplication. Matrix, Transpose of Matrices, Inverse of a Matrix, Rank of a Matrix, Vector and Matrix norms, Eigen value problem: Eigen Values of Symmetric Tri-diagonal Matrix, Householder's Method, The QR Method.

Unit 4: Solution of Systems of Linear Equations: Gauss Elimination Method, Gauss-Jordan Method; Solution of Systems of Non-Linear Equations: Fixed-Point Iteration Method, Newton-Raphson Method,

Books:

1. "Introductory Methods of Numerical Analysis", S.S. Sastry, Prentice Hall India, 3rd Ed.
2. "Computer Applications in Physics", Suresh Chandra, Narosa
3. "Computer Oriented Numerical Methods", V. Rajaraman, 3rd Ed.

1GP4-Electronics Lab (Practical)

Skill Education Course Contents

1ST1- Solar Radiation, Thermal Conversion: Design and Installation-I

Unit 1: General principles of passive solar heating, passive heating of buildings – Some key design elements – Basics of Solar thermal conversion, the direct solar heat gain trombe walls, The water walls, concept of convective air loops and case studies. General principles of passive cooling, ventilation, predicting ventilation in buildings, window ventilation calculations. Re-radiation –Evaporative cooling, mass effect, thermal insulation, load control, air filtration, odor removal and heat recovery in large buildings.

Unit 2: Solar radiation, geometry of the Earth-Sun angles – Solar angles. Calculation of angle of incidence - Surface facing due south, horizontal, inclined surface and vertical surface.

Unit 3.Solar day length – Sun path diagram – Shadow determination. Estimation of Sunshine hours at different places in India. Calculation of total solar radiation on horizontal and tilted surfaces. Prediction of solar radiation availability. Solar thermal power generation

.

Unit 4: Solar thermal engineering, the roof top solar water heater, the pumped solar water heater, the thermo siphon solar water heater, the wave lengths of solar water radiation, direct and diffusion radiation, solar thermal engines, and electricity generation

Books:

1. "Solar Energy Fundamentals and Applications", Garg H.P., Prakash J., Tata McGraw-Hill, 2005.

1ST2– Solar Photovoltaic Principles and Design

Unit 1: Basics of Solar Photovoltaic, Photovoltaic effect, Principle of photovoltaic conversion, Solar Photovoltaic energy conversion and utilization, Fabrication of Photovoltaic Devices, I-V characteristics of a PV module, maximum power point, cell efficiency, fill factor, effect of irradiation and temperature

.

Unit 2: Electrical Characterization of Semiconductor and Photovoltaic Devices**:** 4-point and 2 point probe resistivity**,** Current – voltage characteristics**,** Capacitance – voltage characteristic, Transistor curves**,** Power conversion efficiency

Unit 3: Production process of single crystalline silicon cells, multi crystalline silicon cells, amorphous silicon, cadmium telluride, copper indium gallium di-selenide cells.

Unit 4: PV System Classification - Central Power Station System, Distributed PV System, Stand alone PV system, grid Interactive PV System, small system for consumer applications, hybrid solar PV system, concentrator solar photovoltaic.

Books:

1. "Introduction to Photovoltaic", John R. Balfour, Michael L. Shaw, Sharlave Jarosek., Jones & Bartlett Publishers, Burlington, 2011.
2. "Solar Cell Technology and Applications", Jha A.R., CRC Press, 2010.
3. "Solar Photovoltaic: Fundamentals, Technologies and Application", Chetan Singh Solanki, PHI Learning Pvt., Ltd., 2009.

1 ST3– Semiconductor Devices and Photo Voltaic Theory

Unit 1: Semiconductor properties, Intrinsic and extrinsic and compound semiconductors, energy levels; electrical conductivity; Energy levels, Fermi energy level; Probability of occupation of allowed states; energy density of allowed states; density of electrons and holes, p-type and n-type semiconductors, p-n junction, Zener diode, I-V characteristics of p-n junction and diode equations..

Unit 2: Optical absorption, photo-carrier generation, diffusion and photoconductivity, Solar cell, Physics of Photo Voltaic Semiconductor, Basic mechanisms in photovoltaic devices, equivalent circuit, recombination, fabrication processes, Introduction to Photo Voltaic technologies, Solar cell technology, photo voltaic system engineering, photo voltaic system design guidelines and methodology.

Unit 3: Charge carrier statistics and transport, luminescence, photoconductivity, metal-semiconductor junctions, Junction field-effect transistor (JFET), Metallic oxide semiconductor field effect transistor (MOSFET), bipolar junction transistor (BJT),, laser diodes (LD), tunnel diodes and photovoltaic solar cells.

Unit 4: Crystal lattices, Lattice planes, Basics of Band theory and electronic structures, MOS capacitor, The MOS diode, Schottky contacts; CV profiling.

Books:

1. Semiconductor Devices: Physics and Technology*; S.M. Sze*
2. The Physics of Solar Cells*; Jenny Nelson*

1SP4 – Solar Thermal Training Lab – 1A

Semester – II

2GT1-Basic Electrical Circuits

Unit 1.Circuit theory: Resistors in series and Delta Transportation, Kirchhoff's current and voltage law, simple exercises,

Unit 2. A.C Circuits: Resistance-Inductance-Energy Stored in capacitance –series circuits, RL, RC and RLC circuit. Power Triangle, Series Parallel circuits, Admittance (Exercise). Resonance in A.C Circuits: Series Resistance, Frequency variation, Selectivity, Q Factor, Half Power Frequency–Band Width –Parallel Resistance - Two Branch Parallel Circuits Resistance Variation – Resistance at all frequencies, Tunnel circuit.

Unit 3: Networks Theorem: Superposition Theorem, Maximum Power transfer theorem, Reciprocity Theorem, Thevenin's Theorem, Norton's Theorem, Millman's Theorem (simple exercise), two Port Network.

Unit 4: Power Supplies: Transformer, ratings, specifications , V1/V2=I2/I1=N1/N2. Efficiency and Losses. Rectifiers (Full wave, Half Wave Filters) Regulation (Line and Regulation). Zener diode as Voltage Regulator. Three pin Regulators and black box. Ideal constant voltage source, Ideal constant current source concept). Silicon Controlled Rectifier (SCR): its construction and working.

Books:

1. Electrical Measurement" by Golding

2GT2- Fundamentals of Heat and Mass Transfer

Unit 1: Thermodynamics, heat transfer and of Steady state conduction problems for cases concerning "with internal heat generation" and "without internal heat generation", steady heat flow in a cylindrical pipe.

Unit 2: Heat transfer in two Dimensions Heat transfer through fins/extended surface: examples of some typical industrial cases – numerical examples, Performance evaluation, heat transfer through compound slab, unsteady heat conduction

Unit 3: Phase change process, convection, nucleate or pool boiling, heat exchanger calculation, mass transfer operations, molecular diffusion, inter-phase mass transfer, material balance, humidification process, adsorption and drying kinematics.

Unit 4: Description of various energy conversion equipments, industrial energy conservation, Sankey diagram, some case study of energy conservation, introduction to economic and financial analysis.

Books:

1. Özışık M. N. (1985); *Heat transfer: A basic approach*, McGraw Hill.
2. Incropera F. P. and Dewitt D. P. (2006); *Fundamentals of Heat and Mass Transfer,* Fifth Ed, John Wiley.
3. Lienhard V J. H. and Lienhard IV J. H. (2011); *A Heat Transfer Textbook,* Fourth Edition, Dover Publication
4. Holman J. P. (1992); *Heat Transfer*, Seventh Edition, McGraw Hill

2GT3 - Numerical Analysis & Methods – II

Unit 1: Interpolation**:** Finite differences, Newton's Formulae for interpolation, Gauss's Central Difference formulae, Stirling's Formula Bessel's Formula, Lagrange's Interpolation formula, Hermite interpolation formula, Inverse Interpolation, Double Interpolation, Spline Interpolation, Cubic Spline.

Unit 2: Numerical Differentiation**:** Differentiation by the least square fitting, Differentiation by Lagrange's interpolation, Differentiation by Newton's divided difference interpolation, Differentiation by Gregory-Newton difference interpolation.

Unit 3: Numerical Integration**:** Integration with Lagrange's interpolation, Newton-Cotes expression for integral, Trapezoidal rule, Simpson's one-third rule, Simpson's three-eight rule, Gaussian Quadrature method, Monte-Carlo method, Euler-Maclaurin Formula.

Unit 4: Solution of Differential Equations**:** Taylor series method, Euler method Henn method, Runge-Kutta method, Predictor-corrector method, Runge-Kutta method for second order first degree linear differential equation.

Books:

1. "Introductory Methods of Numerical Analysis", S.S. Sastry, Prentice Hall India, 3rd Ed.
2. "Computer Applications in Physics", Suresh Chandra, Narosa
3. "Computer Oriented Numerical Methods", V. Rajaraman, 3rd Ed.

2ST1- Solar Radiation, Thermal Conversion: Design and Installation-II

Unit 1: Solar thermal power plants Parabolic trough system, distributed collector, hybrid solar-gas power plants, solar pond based electric power plant, central tower receiver power plant.

Unit 2: Radiation measuring instruments, Theory of Flat Plate Collectors

.

Unit 3: Flat plate collectors–liquid and air type, Selective coatings, Advanced collectors**:** ETC, Solar Pond, Concentrators**:** Optical design of concentrators, Solar water heaters, Heat exchangers, Solar dryers, Solar stills, Solar cooling and refrigeration. Solar Concentrating Collectors: Line focusing and Point-focusing concentrators

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Unit 4: Sun Tracking Mechanism.

Books:

1. "Solar Energy Fundamentals and Applications", Garg H.P., Prakash J., Tata McGraw-Hill, 2005.
2. "Principles of Solar Engineering", Yogi Goswami D., Frank Kreith, Jan F. Kreider, Second Ed., Taylor & Francis, 2003
4. "Renewable Energy Engineering and Technologies", Kishore VVN, TERI, 2009.

2ST2 – Power Generation Systems and Applications

Unit 1.System components - PV arrays, inverters, batteries, charge controls, net power meters. PV array installation, operation, costs, reliability, Power electronics for Photo voltaic systems, Photovoltaic power generation systems, Off□grid power control and management systems,

Unit 2: Commercial solar cells, Design of solar PV systems and cost estimation. Case study of design of solar PV lantern, Home lighting and other appliances, solar water pumping systems Grid connected power control and management systems,

Unit 3: PV System Applications**:** Building-integrated photovoltaic units, grid-interacting central power stations, stand-alone PV devices and systems for distributed power supply in remote and rural areas, solar cars, aircraft, space solar power satellites. Socio-economic and environmental merits of photovoltaic systems

.

Unit 4. PV system design for power plant; New generation solar cells and emerging technologies, Solar Photo-catalysis: Mechanism; Kinetics; Nano□catalysts, System design; Performance parameters; Applications.

Books :

1. "Solar Energy", S.P. Sukhatme, J.K. Nayak, Tata McGraw Hill Education Private Limited, New Delhi, 2010.

2. "Concentrator Photovoltaic", Luque A. L. and Andreev V.M., Springer, 2007.

2ST3 – Photonic Devices and Semiconductor Technology

Unit 1: Semiconductor Devices: Introduction to fabrication methods of p-n junction: Growing method, Alloying method, diffusion method.

Unit 2: Crystal growth and epitaxy: Crystal growth, Czochralski technique, Material characterization, crystal characterization: crystal defects. Epitaxial growth techniques: Chemical Vapor Deposition (CVD) and molecular beam epitaxy. Impurity doping: Basic diffusion process, diffusion related processes: lateral diffusion, range of implanted ions, ions distribution, ion stopping, Implant damage and annealing

Unit 3: Lithography and Itching: Optical lithography: clean room, exposure tools, masks, photo-resist, etching process.

Unit 4: Photonic Devices: light emitting diodes, Semiconductor laser, Photodiodes, Photo-detectors (LDR), laser diodes (LD), Tunnel diodes. MOS capacitor, The MOS diode, Schottky contacts; CV profiling.

Books: Semiconductor Devices: Physics and technology by S.M. Sze

2SP4 - Solar PV Training Lab – 1B

Semester III

General Education Course Contents

3GT1 - Digital Electronics - I

Unit1: Number Systems: Introduction to decimal, binary, octal hexadecimal number system, BCD codes, Introversion of binary decimal, BCD, Octal, Hex. Parity Excess-3 Gray and Johnson code, simple binary arithmetic, introduction to access arithmetic

Unit2: Boolean Algebra: Boolean Axioms, D Morgan 's Theorem :Statement verification and application Simple combinational logic implementations .C-Mappings up to four variable (SOP and POS).One compliment half adder full adder interpretation of full adder as subtractor, introduction to MEP (Map Entered Variables)

Unit 3: Logic Gates: Positive and negative Logic, Universal gates and their importance such as AND, OR, NOT, NOR, NAND, EXOR, EXNOR, proof that any logic gate can be implemented by use of universal gates only, symbols and truth table.

Unit 4: Introduction to different Logic Families (ERTL, DTL, TTL, ECL, CMOS), merits and demerits. Case study TTL NAND Gates: Multi-meter Input Transistor phase Splitter .Totem pole and open collector output concepts. Basic concepts of Fan In and Fan Out sinking and sourcing of current.

Books:

"Digital Electronics", Merlin and Leach :

"Digital Principle and Application", Malvino and Leach:
"Digital Electronics", V.K.Jain:

3GT2 – Transducers

Unit1: Philosophy of measurement and error analysis **:**Units and Standards calibration Techniques Classification of errors –classification of errors-error analysis-Statistical Methods, MTBF, MTTR .Static and Dynamic Characteristics **:**Accuracy, Repeatability, hysteresis, etc.

Unit 2: Characteristics of Transducers-Static Calibrations Mathematical model of Transducers - 0, 1^{st}, 2^{nd} order Transducers-Response to Stamp ramp and Sinusoidal inputs.

Unit 3: Variable Resistance Transducers**:** Principle of operational details characteristic and applications of potentiometric–hot wire anemometer-RTD - Thermistor - Humidity sensors. Variable Inductance and Variable Capacitance Transducers**:** Inductive Transducers-LVDT. Pick Up-Capacitive Transducers of different types. Capacitor. Microphone-Floating Cell. Opto electronic Transducer.

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Unit 4: Other Transducers**:** Piezo Electric Transducers –Hall Effect-Ionization Transducers-Magneto restrictive Fiber Optic Transducers –Eddy Currents-Semiconductor Transducers-Electro - Optic Transducers - IC Sensors-Shaft angle Encoder..Digital Transducer - Smart transducers – Their salient features.

Books:

1. "Measurement System Application and Design", Doeblin E. O McGraw Hill Book Co, IV Ed.1990
2. "Instrumentation Devices and Systems", Rangan, C.S, Mani V.S.V and Sarma G.R, Tata McGraw Hill1983.
3. "Instrument Transducers", Neubert H.K.P, Clarenden Press Oxford 1988.
4. "A Course in Electrical and Electronic Measurements and Instrumentation" Sawhaney A.K Dhanpat Rai and Sons, 1995
5. "Transducers and Instrumentation", Murthy DVS, ,Prentice Hall of India Pvt . Ltd. New Delhi, 1995.

3GT3 - Differential Equations

Unit 1: Ordinary Differential Equations(ODEs): Order of a Differential Equation, Solution of Differential Equation, Arbitrary Constants, Mathematical Modeling, Geometrical Meaning of Derivative of a Function, Concept of Direction Field, Isocline and Integral Curve, Separation of Variables, Exact Differential Equation, Integrating Factor, First order Linear Differential Equation, Bernoulli's Equation, Application of Differential Equations

Unit 2: Second Order ODEs; Second Order Homogeneous Linear Differential equation with constant coefficients, Second Order Homogeneous Linear Differential equation with Variable

Coefficients, Non-homogeneous ODEs: Method of undetermined coefficients, Operator technique, Solution by variation of Parameters. Application of second order ODEs

Unit 3: Series Solution of ODEs; Power Series Method, Theory of Power Series Method, Existence of Power Series Solution, Frobenius Method.

Unit 4: Partial Differential Equations**:** First-order equations, Second-order equations, Separation of variables, Laplace and Poisson equations, Wave equation, Heat-Flow or Diffusion partial differential equations.

Books:

1. "Advanced Engineering Mathematics" Erwin Kreyszig
2. "Mathematical Methods for Physicists", Arfken G.B., Weber H.J., Harris F.E., Seventh Ed., Academic Press, India.
3. "Differential Equation" Schaum Series.

3GP4-Logic Gates and Signal Conditioning (Practical) - 1

3ST1 - Materials for Solar Thermal and Photovoltaic Systems

Unit 1:: Electronic and atomic structures, atomic bonding in solids, crystal structure, microstructure, solidification, alloys, substitution and interstitial alloys, history and examples, bronze and brass.

Unit 2: Mechanical and electrical behavior of ceramics, Description of optical and thermal materials of concrete and composite materials, Intrinsic and extrinsic semiconductors, super conductivity and applications.

Unit 3: Characteristics of solar photovoltaic cell, modules, mismatch effects, construction of SPV collector, array and fields.

Unit 4: General and optical properties of Silicon, organic photovoltaic cell (OPV) dye-sensitized solar cell (DSSC) crystalline silicon photovoltaic cell (C-Si) – its structure, analysis and production, Thin-film photovoltaic solar cell (PVTF), Inorganic Thin film solar cell and III-V Solar Cells, concentrating PV arrays, Front surface materials, Encapsulant, Rear surface and Frame materials.

Books:

1. *"Semiconductor Devices: Physics and Technology",* S.M. Sze.
2. "Photovoltaic Materials", Bube R. H. (1989); Imperial College Press.
3. Ramamurtam S., "*Strength of Materials"*, 16th edition, Danpat Rai Publications, 2010.
4. Raghavan V., "*Materials Science and Engineering",* Prentice-Hall India, 2007.
5. Callister W.D., "Materials Science and Engineering", 6th edition, Wiley

3ST2 - Power Electronics for Solar Energy Systems

Unit1: Power system operation, power quality and Stability, Power quality management, frequency management, Influence of PV/WECS on system transient response, Load scheduling.

Unit 2:
Introduction to basic analysis and operation techniques on power electronic system; Funct ional analysis of power converters.

Unit3:
Power systems control using power converters; Electronic conversion systems application t o renewable energy generation systems.

Unit 4: Induction generator, Principle of operation, Grid and stand-alone connections, Limitations of induction generators, Use of induction generators, converter based sources, network voltage management.

Books:

1. Kersting W. H. (2004); Distribution System Modeling and Analysis, Second Edition, CRC Press.
2. Vittal V. and Ayyanar R. (2012); Grid Integration and Dynamic Impact of Wind Energy, Springer.

Reference Book

3. Bollen M. H. and Hassan F. (2011); Integration of Distributed Generation in the Power System, Wiley-IEEE Press.
4. Keyhani A. (2011); Design of Smart Power Grid Renewable Energy Systems, Wiley–IEEE Press.
5. Muhammad H. Rashid. (2004); Power Electronics: Circuits, Devices and Applications, Pearson Prentice Hall Publisher.
6. Gellings C. W. (2009); The Smart Grid: Enabling Energy Efficiency and Demand Response, First Edition, CRC Press.
7. Teodorescu R. Liserre M. Rodriguez P. (2011); Grid Converters for Photovoltaic and Wind Power Systems, First Edition, Wiley-IEEE Press.

3ST3 - Green and Energy Efficient Building

Unit 1: Review of topics on thermal comfort, classification of climate zones, Review of traditional architecture Heat flow calculations in buildings: Unsteady heat flows through walls, roof, windows etc. Direct heat gains through windows. Convective gains/losses, air exchange rates. Gains from peoples, appliances etc, Air conditioning load calculations.

Unit 2: Passive and low energy concepts and applications. Passive cooling/heating concepts, building form and orientation, internal and external shading devices, ventilation, passive concepts for composite climates, evaporation and nocturnal cooling, earth–air tunnel, sky-therm system, solar chimney-based hybrid system.

Unit 3: HVAC systems. Description of different components of HVAC systems. Introduction and use of different building simulation software for modeling of air conditioned spaces such as VISDOE, EPLUS etc.

Unit 4: Rating systems in different countries. Green building rating systems such as LEED and GRIHA. BEE and ECBC.

Books:

1. Eicker U., "Low Energy Cooling for Sustainable Buildings", Wiley, 2009.
2. Kibert C.J. "Sustainable Construction: Green Building Design", 2nd edition, Wiley, 2007.
3. Boecker J., "Integrative Design Guide to Green Building", Wiley, 2009.
4. Means R.S., "Green building: project planning and cost estimating", Kingston, 2006.
5. Gevorkian P., "Alternative Energy Systems in Building Design", McGraw-Hill, 2010.
6. Attmann O., "Green Architecture", McGraw-Hill, 2010.

3SP4-Solar PV Training Lab -1I

Semester IV

4GT1 - Digital Electronics - II

Unit 1: Sequential Logic: Differential Flip Flops such as RS, clocked RS, JK (Race around condition), Master Slave JK D- type and T-Type Flip Flops.

Unit 2: Explain D type as a delay element. Shift Registers Type of Shift Registers SI SO SI PO PI SO shift right and shift left.

Unit 3: Applications**:** Ring counter and Johnson's counter(Twisted Ring), multiple cycle delay element. Asynchronous counter and synchronous counters (Up and Down) Module N counter.

Unit 4: Concepts of counters as frequency dividers .BCD counters. Data Routing Elements, Multiplexer, De-multiplexers, Decoders, Encoders, Tristate, Buffer, Priority Encoder. Display and display Drivers.

Books:

1. "Digital System Principles and Applications", R .J .Tocci:
2. "Digital Computer Fundamentals", T.C. Bartee:

4GT2– Signal Conditioning

Unit 1: Signal Generation and Processing**:** Sine wave Generation (Using OP-Amp also) and amplitude stability, linear Frequency control and quadrature output.

Unit2. Saw-toothwave (Linear) square wave (Schmitt trigger circuit), triangular wave generators, pulse, step and stair case generators. The 555 timer applications.

Unit3: Signal Conditioner**:** Instrumentation amplifier, programmable amplifier, (OTA based) characteristic, linearization, D. C Emphasis on Phase sensitive detectors and thei r importance in extracting signals, Lock-in amplifier, buried under noise.

Unit4.PrecisionRectifiers723,7105,7965,peakdetectors,sampleandHoldCircuits,(aperturetime, acquisitiontimeetc)comparatorsandqualitativeimportanceofLogarithmicamplifiers,Isolationamplifier,OpticalIsolator,referencevoltageandcurrentreference.

Books for Signal Conditioning:

2. "Instrumentation Devices and Systems", Ranger, Mani and Sharma.
3. "Electronic Measurements and Instrumentation ",Olive and Cage.
4. "Electronic Instrumentation and Measuring Techniques", Cooper.
5. "Principle of Active Network Synthesis and Design", G. Daryanari, JohnWilleyandSons1976.
6. "Filter Theory and Design", Sedraand Bracket, Active and Matrix Publisher

4GT3 – Special Functions and Integral Transforms

Unit 1: Legendre's Equation, Legendre Polynomials $\mathbf{P_n(x)}$, Bessel's Equation, Bessel Functions $\mathbf{J_v(x)}$, Bessel Function of second Kind $\mathbf{Y_v(x)}$, Modified Bessel Function, Hermite function, Sturn-Liouville Problems, Orthogonal Functions.

Unit 2: Gamma Functions**:** Definitions, Properties, Beta function, Riemann Zeta Functions, Stirling's Series, Fourier Series.

Unit 3: Integral Transforms**:** Introduction, Fourier Transform and its Properties, Inverse Fourier Transform, Fourier Convolution Theorem, Signal Processing Application, Discreet Fourier Transform,

Unit 4: Laplace Transforms, Inverse Laplace transform, Linearity, s-shifting, Transform of derivatives, Unit Step Function, t-shifting.

Books:

1. "Advanced Engineering Mathematics" Erwin Kreyszig
2. "Mathematical Methods for Physicists", Arfken G.B., Weber H.J., Harris F.E., Seventh Ed.
3. **"**Differential Equations and Their Applications". Second Ed., ZafarAhsan, Publisher- Prentice-Hall of India, New Delhi

4. "Elementary Differential Equations", Ninth Ed., William E. Boyceand Richard C. DiPrima, John Wiley.

4GP4 - Logic Gates, Signal Conditioning & Operational Amplifier Lab. (Practical) - II

4ST1 - Materials for Solar Thermal Systems

UNIT 1: Concepts of stress and strain, Hooke's law, tension, compression and shear. Stress strain diagram and thermal stresses, Elasticity in metals and polymers, plastic deformation, yield stress, shear strength, strengthening mechanisms, effect of temperature, fracture behavior of various materials, failure analysis, solid solutions and phase diagrams.

UNIT 2: Design and development of heat transfer systems – materials for commercial solar thermal applications. Material considerations of design for solar collectors.

UNIT 3: material for special coatings, reflectors, lenses, receivers, tracking and non-tracking concentrator, thermal energy storage, heat exchangers.

UNIT 4: material for solar chimney, solar steam generators, solar ponds and solar still, solar dryer and furnace materials.

Books:

1. "Introduction to Solid State Physics", Charles Kittel.
2. "Photovoltaic Materials", Bube R. H. (1989); Imperial College Press.
3. Ramamrutam S., "*Strength of Materials"*, 16th edition, Danpat Rai Publications, 2010.
4. Raghavan V., "*Materials Science and Engineering",* Prentice-Hall India, 2007.

4ST2 - Solar Energy Grid Integration

Unit 1:
Introduction on electric grid, Introduction to renewable energy grid integration, concept of mini/micro grids and smart grids, developments, Recent Research on Smart Grid.

Unit 2: Power conversion schemes between electric machines and the grid.

Unit 3:
Power control and management systems for grid integration, Synchronizing with the grid; Issues in integration of synchronous generator.

Unit 4:

Electric Systems Modeling: Modeling and simulation of electric systems; Simulation tools, Simulation of grid connected/off grid renewable energy system (PV/WECS); Optimization and grid planning.

Text Book

1. Kersting W. H. (2004); Distribution system Modeling and Analysis, Second Edition, CRC Press
2. Vittal V. and Ayyanar R. (2012); Grid Integration and Dynamic Impact of Wind Energy, Springer

Reference Book

3. Bollen M. H. and Hassan F. (2011); Integration of Distributed Generation in the Power System, Wiley-IEEE Press
4. Keyhani A. (2011); Design of Smart Power Grid Renewable Energy Systems, Wiley–IEEE Press
5. Muhammad H. Rashid., (2004); Power Electronics: Circuits, Devices and Applications, Pearson Prentice Hall Publisher.
6. Gellings C. W. (2009); The Smart Grid: Enabling Energy Efficiency and Demand Response, First Edition, CRC Press
7. Teodorescu R. Liserre M. Rodriguez P. (2011); Grid Converters for Photovoltaic and Wind Power Systems, First Edition, Wiley-IEEE Press

4ST3- Solar Policy and Industrial Practices

Unit 1:
Renewable energy credit schemes, statuary requirements, activities of various states in this regards, tariff determination issue, National Solar Mission, Regulations regarding grid interconnections of renewable energy systems.

Unit 2
Need and advantage of Decentralized energy solutions Emergence of policy and regulatory framework for decentralized electricity (Gokak Committee on DDG under Mop, REST Mission, Power for All, Electricity Act, 11th plan WG on DDG, RGGVY guidelines on DDG, and others, policy framework in other select countries e.g Sri Lanka, China, Thailand etc). Status of grid connected and off grid distributed generation (national and international)

Unit 3:
Scope and challenges in implementing off grid solutions Policy & regulatory Framework for rural electrification Relevant policies and frameworks in other countries Recent off grid programs started by Govt of India for enhancing the rural electrification through off-grid solutions DDG scheme under Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), Remote Village electrification Program, Village energy Security Programme (VESP)Off grid programme under JNNSM

Unit 4:

Use of AutoCAD, PV Syst Generation Analysis, Shading Analysis through Ecotech and Google Sketch up, Cable Sizing tools for Power Generation, Earthing and Lighting Calculation, Complete BoM, Taxation in Solar, policy of different state of sales and purchase of Solar material.
General terminologies used in Solar Industry

Books:

To be added

Paper 4 SP4 - Solar PV Training Lab.-1I

Semester V

5GT1 - Microcontrollers & Microprocessors (Theory)

Unit 1: Microcontrollers**:** Introduction, Read Only Memory (ROM), Random Access Memory (RAM), Electrically Erasable Programmable ROM (EEPROM), Special Function register (SFR), Programme Counter, Central Processing Unit (CPU),

Unit2: Microprocessor Architecture**:** Memory organization: Types of memories (RAM, EPROM, ROM, PROM, DRAM), basic concepts of memory organization (Number of address line required arrangement of memory cells, control line memory extension), concepts of control lines such as Read/Write chip enable. Register to register transfer via data bus.
Arithmetic and Logic Unit (ALU), detail design of as mall 'ALU', an ALU which performs four basic functions (ADD, SUBTTY,OR,AND),Need for decoder integration of ID wit h "ALU" to forman ALU with Control signals.

Unit 3: Control and timing unit**:** Need for this ninth, concept of sequence of execution of an instruction, Integration of all the above to form a C.P.U.
Introduction to 8085 Architecture: Block Diagram, Address Bus, Control Bus, Data Bus, Need to multiplex address and data bus, Memory organization (with emphasis on de-multiplexing, address and data bus during memory read and memory write .Control and timing unit. ALU details, Registers, Flags.

Unit4: Instruction Set**:** Introduction, classification of instruction set, opcode format some basic instructions.(i)Data Transfer instructions, this must include,(a) immediate addressing, (b) Register addressing, (c) Direct addressing, (d) Indirect addressing and (ii) Arithmetic and Logic Instructions. ADD, Sub, AND, OR, XOR, CMP.
Control and Timing: Sequence of execution of instruction. Concept of Instruction Cycle and Machine Cycle. Various type of machine cycle along with associated control and status signals

(Op Code Fetch, memory Read, Memory Write. I/O Read, I/O Write, IO/M,SO,SI,MR,MW/ Detail timing diagram of some instructions.

Unit 5: Advanced Instruction**s:** Branching conditional and unconditional subroutines, concept of stack, need for stack pointer Interfacing**:**
ConcetofInterrupts,classificationofinterrupts,varioustypesofinterrupts(5,5,6,5,7,5)TRAP,Hardware:SoftwareInterruptsRSTO,toRST7instructionassociatedwithinterrupts(RIM,SIM,EI,D10Typical examplesillustratingusage.Interfacing with peripherals**:**
Concept of Input and Output ports of 8255,8279,8253 (General description, how to programme, their usage. Interfacing of A/D and D/A Converters.

Books:

1. **"**Microcontrollers**:** Architecture, Programming, Interfacing and System Design", Raj Kamal, Pearson Education India
2. "8051 Microcontroller: An Applications Based Introduction", David Calcutt, Frederick Cowan, and Hassan Parchizadeh.
3. "Microprocessor Architecture, Programme and Applications", Gaonkar.
4. "Digital Computer Electronics", Albert Paul Malvino (TMH) First Ed.
5. "Microprocessors and Application", Mathur.

5GT2 – Industrial Mathematics (Theory)

Unit 1: Permutation and Combination theory, Binomial theorem, Algebra of sets. Experiments/Models, Ideas of deterministic and non-deterministic models, Definitions of - (i) Sample space, (ii) Discrete sample space: finite and countable infinite, (iii) Event, (iv) Elementary event, (v) Complement of an event, Concepts of occurrence of an event, Algebra of events and its representation in set theory notations. Occurrence of : (i) at least one of the given events, (ii) none of the given events, (iii) all of the given events, (iv) mutually exclusive events, (v) mutually exhaustive events, (vi) exactly one event out of the given events, Examples and Problems.

Unit 2: Discrete and continuous random variables, mathematical expectation, variance, moment about a point, central moment, moment generating function, Binomial, Poisson, Normal and Rectangular distributions.

Unit 3: Two-dimensional random variables, joint distribution functions, marginal distributions, covariance, linear regression and correlation, rank correlation, least square method of fitting regression lines.

Unit 4: Basics of O. R. – Definition of O. R.- Characteristics of O. R.-Scientific methods in O. R. And Decision Making-Scope of O. R. Uses and limitations of O. R. Linear Programming Problem- Formulation of L.P.P, Graphical solutions of L. P.P. and Simplex Method.

Unit 5: Charnes Penalty Method or Big- M Method-Two Phase Simplex method-Problems, Duality in L. P. P.-Concept of duality- Duality and Simplex Method-Problems.

Books:

1) **"**Mathematical Statistics", J. N. Kapur and H. C. Saxena, S. Chand
2) **"**Operations Research", Kantiswarup, P.K. Gupta, Man Mohan, S. Chand & Sons Ltd.
3) **"**Fundamentals of Mathematical Statistics", Gupta and Kapoor, Sultan Chand and Sons, New Delhi.
4) "Introduction to Probability Theory and Its Applications", Vol. I (1963), W Feller, Asian Publishing House, Bombay.

5ST1 - Advanced Solar Thermal Energy Conversion Systems& Applications (Theory)

Unit 1: Flat-plate and evacuated tubular collectors: Effective energy losses; Thermal analysis; Heat capacity effect; performance testing methods: Evacuated tubular collectors, Air flat-plate Collectors: Thermal analysis; Thermal drying, Selective surfaces: Ideal coating characteristics; Types and applications; Anti-reflective coating: Preparation and characterization. Concentrating collector: Classification, design and performance parameters; Tracking systems;

Unit 2: Compound parabolic concentrators; parabolic trough concentrators; Concentrators with point focus; Solar furnaces Parabolic trough systems; Rankine cycle; Parabolic Dish - Stirling System; Combined cycle.

Unit 3: Solar cooling system: Liquid based solar heating system; Natural, forced and gravity flow, mathematical modeling, Vapour absorption refrigeration cycle; Water, ammonia and lithium bromide-water absorption refrigeration systems; Solar operated refrigeration systems; Solar desiccant cooling

Unit 4: Solar thermal energy storage: Sensible storage; Latent heat storage; Thermo-chemical storage; High temperature storage, Designing thermal storage systems, Performances of solar collectors: ASHRAE code; Modeling of solar thermal system components, Design and sizing of solar heating systems: f–chart method, solar thermal system evaluation method.

Unit 5: Solar energy for industrial process heat, Temperature requirements, consumption pattern; solar flat plate water heater and air heater for industrial process heat applications, Solar thermal energy systems: Solar still; Solar cooker: Solar pond; Solar passive heating and cooling systems: Trombe wall; Greenhouse technology: Fundamentals, design, modeling and applications.

Books:

1. "Principles of Solar Engineering", Goswami D. Y. Kreith F. and Kreider J. F. (1999); Taylor and Francis
2. "Solar Engineering of Thermal Processes", Duffie J. A. and Beckman W. A. (2013); Fourth Edition, Wiley.

Reference Books:

1. "Solar Energy, Fundamentals Design, Modeling and Applications", Tiwari, G. N. (2002); Narosa.
2. "Solar Thermal Energy storage", Garg H. P. (1985), D. Reidel Publishing Co.
3. "Solar Thermal Energy Technology",Norton B. (1992); Springer Verlag.
4. "Solar Energy Engineering: Processes and Systems", Kalogirou S. A. (2009); Academic Press.
5. "Renewable Energy: Power for A Sustainable Future", Boyle G. (2012), 3rd Edition, OUP.

5ST2 - Advanced Photovoltaic Solar Energy Systems& Applications (Theory)

Unit 1: Solar cell materials, New generation solar cell materials, metal-semiconductor interface; dark and illumination characteristics; Figure of merits of solar cell; Efficiency limits; Factors affecting the efficiency; Performance parameters and their measurements; Strategies to enhance the efficiency of solar cell, Solar cell fabrication technology: Preparation of metallurgical, electronic and solar grade silicon;

Unit 2: Advance Synthesis Methods: Production of single crystal Silicon: Czokralski (CZ) and Float Zone (FZ) method: Procedure of masking, photolithography and etching; Design of a complete silicon, GaAs, InP solar cell; High efficiency III□V, II□VI multi-junction solar cell; a□Si□H based solar cells; Quantum well solar cell, Thermo-photo-voltaics

Unit 3: New generation solar cells, Organic PV cells, Dye□sensitized solar cells; Working and efficiency limits; emerging solar cell technologies, Solar photovoltaic system design and simulation: Solar cell array system analysis and performance prediction; Shadow analysis: Reliability; Solar cell array design concepts; PV system design; Design process and optimization; Detailed array design; Storage autonomy;

Unit 4: Voltage regulation; Maximum tracking; Array protection and troubleshooting; Introduction to System Advisor Model (SAM),
:
Unit 5: Solar Photocatalytic Detoxification: Mechanism; Advantages; Kinetic model; Nanoparticle, Catalyst: Physical properties, sensitization; System design methodology; Performance parameters; Application for liquid and gas phase organic pollutant mitigation and disinfection.

Books:

1. "Solar Photovoltaics: Fundamentals, Technologies and Applications"' Solanki C. S. (2009), Prentice Hall India
2. "Photovoltaic Solar Energy Generation", Goetzberger A. and Hoffmann V. U. (2005), Springer

Reference Books:

1. "Fundamentals of Solar Cells: PV Solar Energy Conversion", Fahrenbruch A. L. and Bube R. H. (1983); Academic Press
2. "Photovoltaic Materials", Bube R. H. (1989); Imperial College Press.

3. "Solar Cells and their Applications", Partain L. D. (1995*);* John Wiley.
4. "Solar Cell Array Design Handbook", Rauschenbach H. S. (1980); Van Nostrand Reinfold.
5. "Applied Photovoltaics", Wenham S .R. Green M. A. Watt M. E. and Corkish R. (2007); Second Edition, Earthscan

6ST1 - Entrepreneurship and Energy Conservation Management (Theory)

Unit1:Entrepreneurship, type of Entrepreneurs, Qualities of a successful Entrepreneur, Function s of a n entrepreneur .barriers to entrepreneurship, environmental factors influencing entrepreneurship, Entrepreneurial motivation, industry and its classification.
Project Management**:** Meaning of a project, Project Identification Project Report, Network Planning techniques, Basic concept in network analysis and construction of network diagram. Concept of project appraisal. Project appraisal methods, cash flow as cost and benefits, pay-back period, average rate of return. Discounted cash flow techniques, concept of factory design, type of factory buildings, factory layout objective sand types.

Unit2:Method of estimating cost, performance balance sheet and profit and loss account, project appraisal in public enterprise, public investment decision making in India .Privatization sources of finance cost of capital project finance term loans, lease finance sources of short term finance financial institution assisting entrepreneurs. Concept of marketing channel, selecting channel members, alternative channels of distribution, Mercantile agents, Merchant middlemen wholesalers, retailers Phases of Entrepreneurial development program.

Unit3: Step to be taken for small industries, preparation of project report guide lines. Sole proprietorship partnership, joint stock company, factors effecting the choice of organization, meaning of incentives and subsidies. Needs and problems, Schemes of incentives in operation, Machinery on h ire, purchase, transport subsidy, export and imports.

UNIT 4: Energy Conservation Principles**:** Energy scenario – Principles of energy conservation - Commercial and non-commercial energy, primary energy resources, commercial energy production, final energy consumption, Indian energy scenario, sector-wise energy consumption. Energy needs of growing economy, long term energy scenario, energy pricing, energy security, role of energy managers in industries - Energy audit questionnaire – Energy conservation Acts.

UNIT 5: Energy Management and Policy**:** Organizational background desired for energy management persuasion, motivation, publicity role, industrial energy management systems. Energy monitoring and targeting-Elements, data, information analysis and techniques–Energy consumption, production, cumulative sum of differences (CUSUM). Economics of various energy conservation schemes – Energy policy and energy labeling. Energy Management Information Systems (EMIS). Energy policy issues-renewable energy, power sector reforms, restructuring of energy supply sector, energy strategy for future, Energy Conservation Act and National Electricity Policy and Plan.

Books:

1. "Developing Entrepreneurship-A Handbook", T. Venkateswara Rao, Eureka Marketing Group.
2. "Entrepreneurship and Entrepreneurship Development and Planning inIndia", D.N. Mishra, Chugh Publications
3. "Development Bank and New Entrepreneurship in India", P.N. Mishra, National Publishing.
4. "Entrepreneurship in Smalls cale industries", M.C. Gupta, Anmol Publications
5. "How to Start Your Own Small Scale Industry", G.D. Sharma,VisionBooks
6. "Industrial Energy Conservation", Reay, D. A., Pergamon Press, 1st Edition, 2003.
7. "Industrial Energy Management and Utilization", White, L. C.,, Hemisphere Publishers,2002.
8. "Energy Management, Supply and Conservation", Beggs, Clive," Taylor and Francis, 2nd Ed, 2009.
9. "Energy Management Principles", Smith, C.B., Pergamon Press, 2006.
10. "Energy Auditing and Conservation: Methods, Measurements, Management and Case Study", Hamies, Hemisphere, 2003.Trivedi, P.R. and Jolka K.
11. "Energy Management", Trivedi, P.R. and Jolka K.R., Common Wealth Publication, 2002

6ST2 - Decentralization of Energy Systems (Theory)

Unit 1: Centralized and decentralized PV systems; Stand alone, hybrid and grid connected system, System installation, operation and maintenances; Field experience; PV market analysis and economics**.** Need and advantage of decentralized energy systems, Decentralized generation technologies, Costs and choice of technology, demand and benefits, forecasting and program development, Economic and financial analysis of decentralized electrification projects, Decentralized versus Centralized power generation, Traditional power systems, Load curves and Load curve analysis of a village, Demand scheduling,

Unit 2: Optimal design of hybrid energy systems, energy economics and cost optimization of integrated energy systems; Sample problems and case studies, Simulation tools like HOMER, RETSCREEN etc. Scope and challenges in implementing off grid solutions;

Unit 3: Policy and regulatory framework for decentralized electricity in India: Gokak Committee. Integrated Energy Policy, Power for All, Electricity Act, RGGVY, Village Energy Security Programme (VESP), Status of grid connected and Introduction to basic analysis and operation techniques on power electronic systems;

Unit 4: Functional analysis of power converters, Power conversion schemes between solar systems and the grid, Power systems control using power converters; Electronic conversion systems application to renewable energy generation systems, Power and Photovoltaic Power applications

Unit 5: Power control and management systems for grid integration, Synchronizing with the grid; Issues in integration of synchronous generator, induction generator and converter based sources; Network voltage management; Power quality management and Frequency management; Influence of PV/WECS on system transient response, Electric Systems Modeling, Optimization and grid planning.

Books:

1. "Distribution System Modeling and Analysis", Kersting W. H. (2004); Second Edition, CRC Press
2. "Grid Integration and Dynamic Impact of Wind Energy", Vittal V. and Ayyanar R. (2012); Springer

Reference Books:

1. "Integration of Distributed Generation in the Power System", Bollen M. H. and Hassan F. (2011), Wiley-IEEE Press.
2. "Design of Smart Power Grid Renewable Energy Systems", Keyhani A. (2011); Wiley–IEEE Press.
2. "Power Electronics: Circuits, Devices and Applications", Muhammad H. Rashid (2004); Pearson/Prentice Hall Publisher, 3rd Ed.
4. "The Smart Grid: Enabling Energy Efficiency and Demand Response", Gellings C. W. 2009), First Edition, CRC Press.
5. "Grid Converters for Photovoltaic and Wind Power Systems", Teodorescu R., Liserre M., Rodriguez P. (2011), First Edition, Wiley-IEEE Press.
6. "Principles of Solar Engineering", Goswami D.Y. Kreith, F. Kreider J.F., Taylor & Francis, 1999.
7. "Solar Energy, Fundamentals Design, Modeling and Applications", Tiwari G.N., Narosa, 2002.
8. "Solar Engineering of Thermal Process", Duffie J.A. Beckman W.A., John Wiley, 2006
9. "Renewable Energy Engineering and Technologies", Kishore VVN, TERI, 2009

6SP1 - Project Involving Hands-on Training in Manufacturing and Installation of Photo Voltaic System Domestic and in a Solar Power Plant

6SP2- Seminar