Choice of Vocational Courses

There are two vocational courses available in B.Sc. Sem II viz. VC1_1 (PHYVC203 - Solar Photovoltaic Technology) and VC1_2 (PHYVC204 - Opto Electronics -1). A student has to study one of the two vocational courses in Semester II. Similarly, there are two vocational courses available in B.Sc. Sem IV viz. VC2_1 (PHYVC403 - Solar Thermal Energy Conversion) and VC2_2 (PHYVC404 - Opto Electronics -2). If a student has selected vocational course VC1_1 in Semester II then the student has to study vocational course VC2_1 in Semester IV, Similarly, if the student has selected vocational course VC1_2 in Semester II the student has to study vocational course VC2_2 in Semester IV.

Physics B. Sc. Semester II Credits 04

Title of the Paper: PHYVC203 - Solar Photovoltaic Technology

Vocational Paper I (VC1_1)

Course Objectives and Outcomes:

The course

1. Intends to give the necessary and significant learning regarding solar Photovoltaic conversion systems.
2. Covers the fundamental knowledge about the solar cell and preparation techniques.
3. Provides the modern knowledge and on-field practices of solar PV systems.
4. Presents the manual and computer based designing methods of kilowatt to megawatt level photovoltaic systems.

UNIT I

Solar cell physics: p-n junction, homo and hetro-junctions, Metal-semiconductor interface; Dark and illumination characteristics; Figure of merits of solar cell; Variation of efficiency with band-gap and temperature; Spectral response of solar cell; Efficiency limits; Optical properties of solar cell; Different losses and mitigation, Back surface passivation, Passivation with Hydrogen, Parasitic Resistance Effects; Solar cell preparation and processing: Preparation of metallurgical and solar grade Silicon; Production of single crystal Silicon: Czokralski (CZ) and Float Zone (FZ) method; Procedure of masking, photolithography and etching.

UNIT II

Solar Photovoltaic modules: Cell matrix, Lamination and curing, Encapsulation and framing, Testing, Electrical and thermal properties, Module and circuit designing, Identical and non-identical modules, Module mismatching, Shading and hot-spot formation, Environmental effect on PV module performance. Basic terminology of SPV systems; string, array, sub-array, field. designing concept and methods of stand-alone and grid-interactive SPV system, Designing of solar water pumping set, designing and simulation software i.e., PV syst, PV watts, etc.

UNIT III

Observation of current-voltage characteristics of solar cell under different temperature and irradiance conditions. I-V characteristics, Fill-Factor and efficiency of a Mono-Crystalline

silicon photovoltaic module at different solar irradiance. Observation of current variation of a PV module at different loads.
Output power characteristics of a PV module under partial and complete shading.
Observation of illumination and dark characteristics of solar cell.

UNIT IV

Study of the I-V and P-V characteristics of series and parallel combination of solar PV modules.
analysis the spectral response of crystalline solar cell.
Observation of the output power of series connected modules with and without MPPT converter.
Working out power flow calculations of standalone PV system of DC and AC load with battery.
Grid synchronization of solar PV inverter and its performance analysis.

Reference Books and Material:

1. Bent Sorensen, *Renewable Energy,* Academic press, New York.
2. *Tiwari, G N,* Solar Energy, Fundamentals Design, Modeling and Applications, *Narosa, New Delhi.*
3. Green M A, *Third Generation Photovoltics: Advanced Solar Energy*, Springer.
4. *Alan L Fahrenbruch, Richard H Bube, Fundamentals of Solar Cells: PV Solar Energy Conversion, Academic Press, New York.*
5. Larry D Partain Ed, *Solar Cells and Their Applications,* John Wiley and Sons, Inc, New York.
6. Richard H Bube, *Photovoltaic Materials*, Imperial College Press.
7. Rauschenbach H S, Van Nostrand, *Solar Cell Array Design Handbook*, Reinfold Company, New York.
8. Duffie JA, Beckman WA, *Solar Engineering of Thermal Processes,* John Wiley.
9. Goswami *D Y, Frank Kreith and Kreider, Principles of Solar engineering, Taylor and Francis, USA.*

Physics B. Sc. Semester II Credits 04

Title of the Paper: PHYVC204 - Opto Electronics -1

Vocational Paper I (VC1_2)

Course Objectives

This course will give the students an opportunity to learn about different types of optical emission, detection, modulation and opto electronic components and their applications.

Course Outcome

On the completion of this course students would

1. Know the basics of optics and solid state physics .
2. Understand different methods of luminescence, display devices, laser types and their applications.
3. Learn the principle of optical detection mechanism in different detection devices.
4. Understand different light modulation techniques, and the concepts and applications of optical switching.
5. Gain hands-on knowledge about different optoelectronic components. Recording data, plotting of graphs, extraction of relevant information from graphs and identifying the sources of experimental error is also a key outcome along with analyzing and presenting experimental findings through written laboratory reports.

UNIT I

ELEMENTS OF LIGHT AND SOLID STATE PHYSICS:

Wave nature of light, Polarization, Interference, Diffraction, Light Sources. General Introduction to LIGO. Semiconductor Physics and Semiconductor Junction Device.

UNIT II

DISPLAY DEVICES AND LASERS :

Introduction, Photo Luminescence, Cathodoluminescence, Electroluminescence, Injection Luminescence, LED, Plasma Display, Liquid Crystal Displays, Numeric Displays, Laser: Absorption, Emission, Population Inversion, Optical Feedback, Threshold condition, laser applications.

UNIT III

OPTICAL DETECTION DEVICES and OPTOELECTRONIC MODULATORS:

Photo detector, Thermal detector, Photo diodes, Detector Performance. Electro-optic modulators, Optical Switching and Logic Devices

UNIT IV

1. LAB

Experiment 1: Expansion and collimation of laser beam.

Experiment 2: Study of Diffraction Pattern Using a Software Controlled Set-Up.

Experiment 3: Height of a building by Sextant.

Experiment 4: Polarimeter: Specific rotation of sugar solution

Experiment 5: Dispersive power of the material of a prism using spectrometer

Experiment 6: To determine the band gap in a junction diode.

(Any three of the above experiments)

2. Online Virtual Lab Experiment List / Link

Virtual Labs at Amrita Vishwa Vidyapeetham
https://vlab.amrita.edu/?sub=1&brch=189

1. Michelson's Interferometer: Wavelength of laser beam
2. Newton's Rings: Refractive index of liquid
3. Brewster's angle determination
4. Laser beam divergence and spot size

Virtual Labs at Amrita Vishwa Vidyapeetham
https://vlab.amrita.edu/index.php?sub=1&brch=281

5. Spectrometer: Refractive index of the material of a prism
6. Spectrometer: Dispersive power of a prism
7. Spectrometer: Determination of Cauchy's constants
   Diffraction Grating

1. https://vlab.amrita.edu/index.php?sub=1&brch=201
2. http://vlabs.iitkgp.ac.in/be/#

TEXTBOOK

1. J. Wilson and J.Hawks, "Opto Electronics – An Introduction", Prentice Hall of India Pvt. Ltd., New Delhi, 1995.

REFERENCES

1. Laser Fundamentals: William T. Silfvast, Cambridge University Press
2. Optical Electronics: A. Ghatak and K. Thyagrajan , Cambridge University Press
3. Laser Physics: Joseph H Eberly and Peter W Miloni, Wiley
4. Principle of Lasers: Orazio Svelto, Springer
5. Physics of Semiconductor Devices: SM Sze, Y Li and Kwok K NG; Wiley
6. Anchal Srivastava, R.K. Shukla and T.P. Pandya, "Introduction to Optics", New Age International (P) Limited Publishers
7. R.K. Shukla and Anchal Srivastava, "Practical Physics", New Age International (P) Limited Publishers

Physics B. Sc. Semester IV Credits 04

Title of the Paper: PHYVC403 - Solar Thermal Energy Conversion

Vocational Paper II (VC2_1)

Course Objectives and Outcomes:

The course

1. Intends to give the necessary and significant learning regarding solar energy conversion systems operation and installation.
2. Covers the information about the solar radiation used for solar energy systems.
3. Provides the modern knowledge and on-field practices of solar thermal systems.
4. Presents the designing methods of kilowatt to megawatt level solar thermal energy systems in by in-situ methods.

UNIT I

Solar radiation: its measurement and prediction. The Solar Constant; Radiation solar intensity at earth surface; Direct and diffuse radiation; Solar geometry; Sun-path diagrams**. A**vailable solar radiation: Pyranometers, Pyrheliometric scales, Estimation solar radiation on horizontal surface; Radiation on sloped surfaces: Isotropic sky model, Anisotropic sky; Solar radiation Data**.**
Solar thermal energy conversion: Principle of direct and indirect energy conversion; Flat plate collectors: Effective energy losses; Thermal analysis; Heat capacity effect; Testing methods; Evacuated tubular collectors; Air flat plate collectors: types; Thermal analysis; Thermal drying.

UNIT II

Introduction and classification of concentrating collectors, Thermodynamic limits to concentration, parabolic geometries, paraboloid geometries (dish), Solar concentrator mountings, Solar incident angle for different concentrator mountings, Performance analysis of cylindrical parabolic collector, Compound parabolic collector (CPC). ASHRAE code; Modeling of solar thermal system components and simulation; Design and sizing of solar heating systems: f–chart method and utilizability methods of solar thermal system evaluation.

Fundamentals, design and applications of Solar still; Solar cooker; Solar dryer; Solar Pond and other solar thermal systems.

UNIT III

Observation of the total solar energy for a day or for a specified period with different inclination i.e., horizontal surface, latitude and 45° tilt, and also calculate the tilt factor sunshine hours.
Analysis of the thermal performance of a Box-Type Solar Cooker: without load and with load.
Determination of First and Second Figures of Merit of a Box-Type Solar Cooker.
Total thermal heat gain and efficiency evaluation of a Single Basin Solar Still.

UNIT IV

Evaluation of U_L, F_R, η of Solar Thermal Flat Plate Collector in Thermosyphonic Mode of Flow at different Radiation Levels.
To conduct the heating and cooling tests on a paraboloid concentrator solar cooker to determine its Optical Efficiency Factor, Heat Loss Factor and stagnation test.
Study of the Performance of a Rectangular Dish Type Solar Cooker with Water Heater Through Stagnation Temperature Test and Solar Water Heating Test.

Reference Books and Materials:

1. *Sukhatme S P, Solar Energy: principles of Thermal Collection and Storage, TataMcGraw-Hill.*
2. Duffie JA, Beckman WA, *Solar Engineering of Thermal Processes,* John Wiley.
3. Goswami *D Y, Frank Kreith and Kreider,* Principles of Solar engineering, *Taylor and Francis, USA.*
4. Garg H P, Prakash S, *Solar Energy: Fundamental and Application,* Tata McGrow-Hill, New Delhi.
5. Kreith F, Kreider J F, *Principles of Solar Engineering,* McGraw-Hill.
6. Kreider J F, Kreith F, *Solar Energy Handbook,* McGraw-Hill.
7. Bent Sorensen, *Renewable Energy,* Academic press, New York.
8. *Tiwari, G N, Solar Energy, Fundamentals Design, Modeling and Applications, Narosa, New Delhi.*

Physics B. Sc. Semester IV Credits 04

Title of the Paper: PHYVC404 - Opto Electronics -2

Vocational Paper I (VC2_2)

Course Objectives

This course will give in-depth knowledge of Optical fibers & their fabrication, optical fiber communication, sensors, switches, optical sources and detectors.

Course Outcome

On the completion of this course students would

1. Know the basics of solid state physics and fiber optics.
2. Learn the principle of optical detection mechanism in different detection devices.
3. Understand transmission in optical fibers.
4. Gain experimental knowledge about various aspects of fibers and optical communication. Recording data, plotting of graphs, extraction of relevant information from graphs and identifying the sources of experimental error is also a key outcome along with analyzing and presenting experimental findings through written laboratory reports.

UNIT- I

Optical fiber Communication:

Historical development, The general system, Advantages of optical fiber communication, Optical fiber waveguides: Ray theory transmission,, Phase and group velocity, Step index fibers, Graded index fibers, Single mode fibers, Cutoff wavelength, Fiber Materials and fabrication methods, Photonic crystal fibers.

UNIT-II

Transmission characteristics of optical fiber:

Attenuation, Material absorption losses, Scattering losses, Fiber bending losses, Dispersion, Chromatic dispersion, Intermodal dispersion: Multimode step index fiber, Fiber alignment and fiber joint loss, Fiber splices, Fiber connectors, Fiber couplers.

UNIT- III

Optical sources and Photodetectors:

Light Emitting diodes: LED Structures,
Light Source Materials, Quantum Efficiency and LED Power Modulation.

Laser Diodes: Modes and Threshold conditions, External Quantum Efficiency, Resonant frequencies, Laser Diode structures and Radiation Patterns.

Principle of Photodiode, Photodetector noise, Detector response time.

UNIT - IV

LAB:

Experiment-1 To Study the Characteristics of LED and Pin Photo Detector.
Experiment-2 To Study bending Losses In An Optical Fiber.
Experiment-3 To Study the Noise in an Optical Receiver.

Online virtual lab

Experiments related to optical fibers, sources and detectors on the following links:

1. https://vlab.amrita.edu/index.php?sub=1&brch=201
2. http://vlabs.iitkgp.ac.in/be/#

TEXTBOOK

1. Keiser, G., Optical Fiber Communications, McGraw-Hill International. (2000).

REFERENCES

1. Seniors, J.M., Optical Fiber Communications – Principles and Practice, PrenticeHall of India, (1996).
2. Cherin, A.H., An Introduction to Optical Fibers, McGraw Hill Book Company, (1983).
3. Yariv, A., Quantum Electronics, Wiley, (1989).
4.Optical Electronics: A. Ghatak and K. Thyagrajan (Cambridge University Press)
5. Fiber Optics and Optoelectronics: R P Khare: Oxford University Press
6.Optical fiber Communication Systems:R.K. Shukla;MKSES Publication