

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 15: PHOTONIC DEVICES AND POWER ELECTRONICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Photonic Devices and Power Electronics Physics DSE 15	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Analog electronics

LEARNING OBJECTIVES

This paper aims to provide students with in-depth understanding of the principles, concepts, and applications of photonic devices and power electronics. The course covers a range of topics, including, semiconductor lasers, fibre optics, power diodes, power MOSFETs, and power electronics applications. Students will develop the necessary knowledge and skills to design and analyse various photonic and power electronic devices and systems. The course also emphasizes the practical aspects of device design, fabrication, and characterization, preparing students for real-world challenges and opportunities in these fields.

LEARNING OUTCOMES

Upon completion of the course on Photonic Devices and Power Electronics, students are expected to achieve the following learning outcomes.

- Understand the basic principles and concepts of photonic devices and power electronics, including semiconductor lasers, fibre optics, power diodes, power MOSFETs, and power electronics applications.
- Develop the necessary knowledge and skills to design and analyse various photonic and power electronic devices and systems.
- Gain practical experience in device design, fabrication, and characterization.
- Apply the knowledge and skills learned in the course to real-world challenges and opportunities in the fields of photonics and power electronics.
- Develop problem-solving skills, critical thinking skills, and the ability to apply scientific and engineering principles to practical problems.
- Understand the ethical considerations and professional responsibilities associated with the development and use of photonic and power electronic devices and systems.
- Overall, students will gain a comprehensive understanding of photonic devices and power electronics and be well-equipped to pursue careers in these fields or continue their studies at the graduate level.

SYLLABUS OF PHYSICS DSE 15

THEORY COMPONENT

Unit – I

(4 Hours)

Classification of photonic devices: Radiative transition and optical absorption. Light Emitting Diodes (Construction, materials and operation)

Semiconductor LASER: Condition for amplification, laser cavity, LASER diode.

Unit – II (8 Hours)

Photodetectors: Photoconductor, photodiodes (p-i-n, avalanche) and photo transistors, quantum efficiency and responsivity

Solar Cell: Construction, working and characteristics.

LCD Displays: Types of liquid crystals, Principle of Liquid Crystal Displays, applications, advantages over LED displays.

Unit – III (4 Hours)

Introduction to Fiber Optics: Element of an Optical Fiber Transmission link- Optical Fiber Modes and Configurations, Overview of Modes -Single Mode Fibers-Graded Index fiber structure.

Unit – IV (8 Hours)

Power Devices: Need for semiconductor power devices, Power MOSFET (qualitative); introduction to family of thyristors; Silicon Controlled Rectifier (SCR) - structure, I-V characteristics, Turn-On and Turn-Off characteristics, ratings, Gate-triggering circuits; DIAC and TRIAC- Basic structure, working and V-I characteristics

Insulated Gate Bipolar Transistors (IGBT): Basic structure, I-V Characteristics, switching characteristics, device limitations and safe operating area (SOA)

Unit – V (6 Hours)

Applications of SCR: Phase controlled rectification, AC voltage control using SCR and Triac as a switch. Power Invertors- Need for commutating circuits and their various types, dc link invertors, Parallel capacitor commutated invertors.

References:

Essential Readings:

- 1) Optoelectronics, J. Wilson and J. F. B. Hawkes, 1996, Prentice Hall India
- 2) Optoelectronics and Photonics, S. O. Kasap, 2009, Pearson Education
- 3) Electronic Devices and Circuits, D. A. Bell, 2015, Oxford University Press
- 4) Introduction to fibre optics, A. K. Ghatak and K. Thyagarajan, 1998, Cambridge University Press
- 5) Power Electronics, M. D. Singh and K. B. Khanchandani, Tata McGraw Hill.

Additional Readings:

- 1) Power Electronics, J. S. Chitode, Technical Publications
- 2) Basic Electrical and Electronics Engineering, R. Saravanakumar V. Jegathesan and K. V. Kumar, Wiley
- 3) Power Electronics: Essentials & Applications, L. Umanand, Wiley

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

- 1) Diffraction experiments using a LASER.
- 2) To determine characteristics of (a) LEDs, (b) Photovoltaic cell and (c) Photodiode.
- 3) To study the Characteristics of LDR and Photodiode with (i) Variable Illumination

- intensity, and (ii) Linear Displacement of source.
- 4) To measure the numerical aperture of an optical fiber.
 - 5) Output and transfer characteristics of a power MOSFET.
 - 6) Study of I-V characteristics of SCR.
 - 7) SCR as a half wave and full wave rectifier with R and R - L loads.
 - 8) AC voltage controller using TRIAC with UJT triggering.
 - 9) Study of I-V characteristics of DIAC.
 - 10) Study of I-V characteristics of TRIAC

References for laboratory work:

- 1) Power Electronics, P. C. Sen, Tata McGraw Hill.
- 2) Power Electronics Circuits, Devices & Applications, 3rd edition, M. H. Rashid, Pearson Education
- 3) A Textbook of Electrical Technology, Vol-II, B. L. Thareja and A. K. Thareja, S. Chand.