

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 16c: LASER PHYSICS AND ITS APPLICATIONS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Laser Physics and its Applications PHYSICS DSE 16c	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Waves and optics paper of this course or its equivalent. Basic idea of energy levels in atoms and molecules

LEARNING OBJECTIVES

Laser physics is a branch of optics that covers the fundamental and applied aspects of laser science. Laser is an acronym for ‘Light Amplification by Stimulated Emission of Radiation’. This radiation has some specific properties different from the common light. The main objective of this course is to introduce the basic principle of its production, its types, the different kinds and techniques of laser devices and applications of laser in various fields including research, high energy applications, medical applications, industrial applications, and nuclear science. Also to perform experiments and to measure some physical quantities based on the experiments using lasers.

LEARNING OUTCOMES

After completing this course, students should be able to,

- Understand the nature of interaction of radiation with matter in the form of absorption of light, spontaneous and stimulated emission of radiation.
- Understand the principle of laser action, including population inversion, metastable states, gain medium, optical pumping, feedback mechanism and threshold condition for laser beam generation
- Understand the various types of lasers such as three and four-level lasers
- Understand various characteristic properties of lasers and how they are utilized in different applications
- Know the importance of lasers in holography and in fibre optics
- Perform some experiments based on the laser technique and to be able to measure some quantities through these experiments

SYLLABUS OF PHYSICS DSE 16c

THEORY COMPONENT

Unit 1 – Introduction

(12 Hours)

Planck’s theory of radiation (qualitative idea), energy levels, absorption process, spontaneous and stimulated emission processes, theory of laser action, population inversion, Einstein’s A and B coefficients of transition, optical pumping, optical amplification, threshold for laser oscillation, line shape function (various line broadening mechanisms: collisional broadening, natural broadening, Doppler broadening), coherence (temporal and spatial type, role of

coherence in laser action), optical resonator (different configurations and stability condition)

Unit 2 – Types of Laser

(8 Hours)

Doped insulator laser (Nd:YAG laser, Ruby laser)

Semiconductor lasers (GaAs laser): Energy bands and carrier distribution in semiconductors, absorption and emission in a semiconductor, optical gain, laser oscillation, threshold current density, power output

Gas lasers: He-Ne laser, noble gas ion laser, carbon dioxide laser

Unit 3 – Applications of Laser

(10 Hours)

Properties of laser light: Mono-chromaticity, directionality, line width, beam coherence, intensity, focussing

Applications: Measurement of distance (interferometry method, beam modulation telemetry), Holography (basic principle, coherence, recording and reconstruction method, white light reflection hologram, application in microscopy and character recognition), medical applications, laser tweezers, high energy applications, industrial applications, laser induced nuclear fusion

References:

Essential Readings:

- 1) Laser Physics, M. Sargent, M. O. Scully and W. E. Lamb Jr., 1974, Western Press
- 2) Laser Physics and Spectroscopy, P. N. Ghosh, 2016, Levant Books, India
- 3) Lasers: Fundamentals and applications, K. Thyagarajan and A. K. Ghatak, 2010, Tata McGraw Hill
- 4) Optical systems and processes, J. Shamir, 2009, PHI Learning Pvt. Ltd.
- 5) Fundamental of optics, A. Kumar, H. R. Gulati and D. R. Khanna, 2011, R. Chand and Co. Publications
- 6) Optics, E. Hecht, 4th edition, 2014, Pearson Education
- 7) Laser applications, M. Ross, 1968, McGraw Hill

Additional Readings:

- 1) Physics for scientists and engineers with modern physics, Jewett and Serway, 2010, Cengage Learning
- 2) Optical Physics, A. Lispon, S. G. Lipson and H. Lipson, 4th edition, 1996, Cambridge University Press
- 3) Fibre optics through experiments, M. R. Shenoy, S. K. Khijwania, et.al. 2009, Viva Books
- 4) Industrial applications of lasers, J. F. Ready, 2nd edition, 1997, Academic Press
- 5) Semiconductor optoelectronics, J. Singh, 1995, McGraw Hill

PRACTICAL COMPONENT

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

At least six experiments to be performed from the following list

- 1) To determine the wavelength and angular spread of laser light by using plane diffraction grating.
- 2) To determine the wavelength of laser source using diffraction of single slit.
- 3) To determine the wavelength of laser source using diffraction of double slits.

- 4) To determine the grating radial spacing of the compact disc by reflection using He-Ne or solid state laser.
- 5) To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser.
- 6) To find the polarization angle of laser light using polarizer and analyser
- 7) To measure the numerical aperture of an optical fibre
- 8) To study the variation of the bending loss in a multimode fibre
- 9) To study thermal expansion of quartz using laser
- 10) To study the characteristics of solid state laser

References for laboratory work:

- 1) Advanced Practical Physics for students: B. L. Flint and H. T. Worsnop, Asia Publishing
- 2) Optoelectronics: An introduction, 3rd edition, 1998, Pearson Education
- 3) Introduction to fibre optics, A. K. Ghatak and K. Thyagarajan, 1998, Cambridge University Press