MANGALORE UNIVERSITY

Department of Physics

MSc Physics

PHH 551: LASER PHYSICS, VACUUM TECHNIQUES AND CRYOGENICS

(52 Hrs.)

Course outcome

CO1 On completion of this course, the candidate would be able to deal with lasers for variety of applications as the theory part is dealtwith effectively.

CO2 All the fields having laser applications would be easier for the candidate to understand after studying this part of the course.

CO3 The candidate to understand any vacuum technique-based experiments.

CO4 The knowledge of vacuum systems is useful in food processing and packaging industries where the tightness of a package is often tested under vacuum and the equipment employed for food analysis is always operated with vacuum pumps.

CO5 The study on cryogenics would help students to understand the behaviour of materials in very low temperature. This would make the candidate to be ready for cryogenic industry related employments with basic knowledge on the topics.

Unit I Lasers and non-linear optics

Lasers - introduction - directionality, intensity, monochromaticity, coherence.

Einstein coefficients - stimulated emission. Basic principles of lasers - the threshold condition - laser pumping.

Some specific laser systems - Neodymium lasers - He-Ne laser - ion lasers - CO_2 laser - Semiconductor lasers - dye lasers - chemical lasers - X ray lasers, free electron laser, Q switching. [13 hrs]

Unit II Holography and Non-linear optics

Principle of holography - some distinguishing characteristics of holographs - practical applications of holography.

Non-linear optics: harmonic generation - second harmonic generation - phase matching - third harmonic generation Z scan technique - optical mixing - parametric generation of light - self focussing of light. Electro optic effect.

Multiquantum photoelectric effect - two photon processes - multiphoton processes - three photon processes. [13 hrs]

Unit III Vacuum techniques

Units of vacuum - vacuum spectrum (ranges - low - medium - high - ultra high). Applications - freeze drying - vacuum coating - industrial applications. Conductance of pipes - pumping speed - throughput - pumpdown time.

Vapour pressure - vacuum gauges and the relevant range of vacuum - Pirani gauge - thermocouple gauge - Pennning gauge.

Vacuum pumps - rotary vane pump (pumping speed and ultimate pressure) - oil diffusion pump - baffle and trap - cryopump - turbomolecular pump. Vacuum feedthroughs - vacuum valves (diaphragm valve, slide valve, ball valve).[13 hrs]

Unit IV Cryogenic techniques

Overview of the techniques of liquefaction of gases (Nitrogen, Hydrogen and Helium). Gas purification - stirling cycle refrigeration and liquefaction of helium.

Properties of cryogenic fluids (Nitrogen and Helium 4). Storage and transfer of cryogenic fluids: Dewars for nitrogen and helium. Liquid level indicators and gauges.

Measurement of temperature: Resistance thermometers (metal, alloys & semiconductors). Thermocouple - (Au + Fe) Vschromel. Magnetic thermometer.

Cooling by evaporation of helium 4 and helium 3 - cooling by adiabatic demagnetisation. Cryostats for low temperature experiments.

Applications of cryogenics: Hydrogen bubble chamber - Rocket propulsion system - superconducting magnets. [13 hrs]

Text Books:

1. Silfvast W T, 'Laser Fundamentals' (Cambridge University Press, 1998)
2. Ghatak A K and Thyagarajan, 'Optical Electronics' (Cambridge University Press 1991)
3. Laud B B, 'Lasers & Nonlinear Optics' (Wiley Eastern, 1985)
4. Mills D L, 'Nonlinear Optics – Basic Concepts' (Narosa Publishing, 1991)
5. Roth A, `Vacuum Technology', II Edn. (North Holland, 1982)
6. Barron R F, `Cryogenic Systems' II Edn. (Oxford University Press, 1985)
7. Wilks J and Betts D S, `An Introduction to Liquid Helium' (Oxford University Press, 1987)

Reference Books:

1. Shen Y R, 'The Principles of Nonlinear Optics' (John Wiley, 1984)
2. Boyd R W, 'Nonlinear Optics' (Academic Press, 1992)
3. Zernike F & Midwinter, 'Applied Nonlinear Optics' (Wiley, 1973)
4. Oshea D C, Callen W R & Rhodes W T, 'Introduction to Lasers & Their Applications' (Addison Wesley, 1977)
5. Harris N S, `Modern Vacuum Practice' (McGraw Hill, 1989)
6. O'Hanlon J F, `A User's Guide to Vacuum Technology' (John Wiley, 1980)
7. West C D, `Principles and Applications of Stirling Engines' (Van Nostrand Reinhold, 1986)