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| Programme | B.Sc. Physics Honours | | | | |
| Course Title | OPTICS AND LASERS | | | | |
| Type of Course | Minor (GROUP IV: OPTICAL PHYSICS) | | | | |
| Semester | II | | | | |
| Academic Level | 100 - 199 | | | | |
| Course Details | Credit | Lecture per week | Tutorial per week | Practical per week | Total Hours |
| | 4 | 3 | - | 2 | 75 |
| Pre-requisites | 1. Basics of Physics and Chemistry (Plus Two Level) | | | | |
| Course Summary | This course explores light's properties, reflection, refraction, and applications in phenomena like interference, diffraction, polarization, and lasers. | | | | |

Course Outcomes (CO):

| CO | CO Statement | Cognitive Level* | Knowledge Category# | Evaluation Tools used |
|-----|--|------------------|---------------------|--|
| CO1 | Explain the fundamental properties of light, including reflection, refraction, and the electromagnetic spectrum. | U | C | Instructor-created exams / Quiz |
| CO2 | Apply the laws of reflection and refraction to solve problems involving mirrors and lenses. | Ap | P | Practical Assignment / Observation of Practical Skills |
| CO3 | Analyze the behavior of light waves using concepts like interference and diffraction. | An | C | Practical Assignment/ Seminar Presentation / Group Tutorial Work |

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| CO4 | Distinguish between Fresnel and Fraunhofer diffraction and explain how they affect light propagation. | An | C | Instructor-created exams / Home Assignments |
| CO5 | Recognize different types of polarization and explain methods for producing and manipulating polarized light. | U | P | Instructor-created exams / Home Assignments |
| CO6 | Apply the knowledge of optics and lasers to understand real-world applications in different fields. | E | P | Viva Voce |
| * - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M) | | | | |

Detailed Syllabus:

| Module | Unit | Content | Hrs (45 +30) | Marks (70) |
|---|---------------------|---|--------------------|---------------|
| I | Introduction | | 7 | 15 |
| | 1 | Properties of light, Laws of reflection, laws of refraction | 2 | |
| | 2 | Refractive index, Optical path, Electromagnetic spectrum and visible light | 3 | |
| | 3 | Photons, Dual nature of light | 2 | |
| Sections 1.5 – 1.12, Book 1 | | | | |
| II | Ray optics | | 10 | 15 |
| | 4 | Reflection at plane Mirrors | 1 | |
| | 5 | Reflection at spherical mirror: Basic terms and sign convention, spherical mirror equation (No derivation) , Focal point and focal length | 2 | |
| | 6 | spherical mirror equation Applied to concave mirror convex mirror and plane mirror | 3 | |
| | 7 | Refraction at spherical surfaces, Gaussian relation | 2 | |
| | 8 | Lens equation, Lens maker's equation. | 2 | |
| Sections 3.3, 3.4, 3.12, 4.8 - 4.10, Book 1 | | | | |
| III | Wave optics | | 20 | 25 |

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| | 9 | Interference, Young double slit experiment | 2 | |
| | 10 | Coherence and conditions for interference | 1 | |
| | 11 | Interference in thin parallel films | 2 | |
| | 12 | Interference in wedge shaped film, Angle of wedge and thickness of spacer, Colour of thin films | 2 | |
| | 13 | Newton's rings: determination of wavelength of light | 2 | |
| | 14 | Diffraction: Difference between diffraction and interference, Fresnel and Fraunhofer type diffraction | 1 | |
| | 15 | Fraunhofer diffraction at a single slit, double slit (Calculus method is excluded), Plane diffraction grating. | 3 | |
| | 16 | Polarization: Types of polarization, Brewster's law | 2 | |
| | 17 | Production of plane polarized light | 1 | |
| | 18 | Polarizer and analyser, Malu's law, Double refraction | 2 | |
| | 19 | Optical activity and specific rotation | 2 | |
| | Section 14.4 – 14.7, 15.2, 15.5, 15.6, 17.6 - 17.7, 18.1, 18.2, 18.4, 18.7, 20.1, 20.2, 20.5, 20.6, 20.8 - 20.11, 20.27 - 20.29, Book 1 | | | |
| IV | Quantum optics | | 8 | 15 |
| | 20 | Lasers, Thermal equilibrium, Absorption of a Photon, Spontaneous emission, Stimulated emission, Population inversion | 3 | |
| | 21 | Components of Laser and lasing action | 2 | |
| | 22 | Ruby laser, Nd-YAG laser, Helium Neon laser, Carbon dioxide laser, semiconductor laser. | 3 | |
| | Sections 22.1, 22.3, 22.4, 22.7, 22.8, 22.9, 22.14, 22.15, Book 1 | | | |
| V | PRACTICALS | | 30 | |
| | Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7 th experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course. Necessary theory of experiments can be given as Assignment/ Seminar. | | | |

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| 1 | <p>Determine the refractive index of (a) given liquid and (b) the material of a lens, by forming a liquid lens.</p> <ul style="list-style-type: none"> Through this experiment the students are expected to get the concepts of image formation, combination of lenses and radius of curvature of the surface of lens. Determine the radius of curvature of the lens by Boy's method and hence calculate the refractive indices. | | |
| 2 | <p>Determine the focal length of the combination of two lenses separated by a distance.</p> <ul style="list-style-type: none"> Determine the focal lengths, f_1 and f_2 of the two lenses using an illuminated cross-slit screen holder, nodal slide (for placing the lenses) and plane mirror arrangement. Place the two lenses separated by a distance d, determine the focal length, F of the combination and verify the relation $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$ The combination of the lenses in the eyepiece of the spectrometer/ travelling microscope may be used for the study. https://www.youtube.com/watch?v=IOIEEtyNPBg https://www.youtube.com/watch?v=tNo4Ipk74SU | | |
| 3 | <p>Determination of the dispersive power of a solid prism using a spectrometer.</p> <ul style="list-style-type: none"> Find the angle of the prism and the angle of minimum deviation for prominent lines of the mercury spectrum using a spectrometer. Calculate the refractive indices corresponding to the colors and find the dispersive power of the material of the prism for two pairs of wavelengths. | | |
| 4 | <p>Refractive indices of quartz prism using spectrometer.</p> <ul style="list-style-type: none"> Determine the refractive indices of quartz for the ordinary and extraordinary rays of a sodium vapour lamp by arranging the quartz prism at minimum deviation position in the spectrometer. Verify the polarizations of the ordinary and extraordinary rays using a polaroid. | | |
| 5 | <p>Determination of wavelengths of mercury spectrum using diffraction grating and spectrometer.</p> <ul style="list-style-type: none"> Arrange the grating at normal incidence. Standardize the grating using the green line of mercury and then find the wavelengths of other prominent lines of the spectrum. | | |
| 6 | <p>Newton's rings-determination of the wavelength of sodium light</p> <ul style="list-style-type: none"> Form of Newton's rings in the air-film in between a plano-convex lens and a glass plate using sodium-source. | | |

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| | <ul style="list-style-type: none"> Determine the radius of curvature by Boy's method and determine the wavelength of the source. Optional: In experiment 5 and 6, record a short video of the interference pattern, calibrate the video using scale marked on the glass plate, analyse the video using Tracker tool. From the intensity profile get the locations of the dark rings and calculate the wavelength of the source/thickness of the sample https://physlets.org/tracker/. https://www.youtube.com/watch?v=UCCPkJpUQEw | | |
| 7 | Air wedge-determination of the radius of a thin wire/human hair/thin foil. <ul style="list-style-type: none"> Form interference fringes using sodium-source, in the air-film in between wedge formed by placing the given sample between the glass plates. Measure the positions of the successive dark bands using a travelling microscope and determine the angle of the wedge and thickness of the sample given. | | |
| 8 | Wavelength of laser using grating <ul style="list-style-type: none"> The laser light diffracted from the transmission grating is allowed to fall on a screen and record the maxima points in a paper and calculate the wavelength of the laser. Determine the number of lines/ meter of the grating using the green line of the mercury | | |
| 9 | Single slit diffraction using laser - Determination of slit width. <ul style="list-style-type: none"> The laser light diffracted from the narrow slit is allowed to fall on a screen and record the maxima or minima points in a paper. From the width of the central maxima or the position of minimum intensity points, calculate the slit width. Verify the slit width using a traveling microscope. Wavelength of laser can be found using diffraction grating of known N. | | |
| 10 | Study the specific rotation of the sugar solution using a polarimeter. <ul style="list-style-type: none"> Determine the specific rotation corresponding to different concentrations of the sugar dissolved in water. Draw a graph between rotation and concentrations and verify the linear relationship. | | |
| 11 | Verification of Malus's law using polarizer, analyzer and photo detector <ul style="list-style-type: none"> Unpolarized light is allowed to pass through a polarizer and is observed through an analyzer. Vary the angle between the axes of polarizer and analyzer and measure the intensity of the light (current output of the photodetector). | | |

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| | | <ul style="list-style-type: none"> Plot $\theta - I$ and $\cos^2 \theta - I$ graphs and verify the Malus's law. A flat computer monitor (or LCD TV screen) in plain white color can be used as the source of linear polarized light. The ambient light sensor of the smartphone and the orientation sensor of the smartphone can be used to measure the illuminance and the angles respectively. A small piece of polarizer (a square of about 1 cm side) from an old calculator's display was placed over the ambient light sensor as analyser. https://arxiv.org/pdf/1607.02659 | | |
| 12 | Spectrometer-Determination of the Cauchy's constants of the given prism | <ul style="list-style-type: none"> Find the angle of the prism, the minimum deviation angles of the prominent lines of the mercury spectrum and hence calculate the refractive indices for the colors. Determine A and B from the $\mu - \frac{1}{\lambda^2}$ graph. | | |
| 13 | Determine the numerical aperture (NA) of an optical fiber using a laser | <ul style="list-style-type: none"> Couple the light from the laser source onto one of the fiber ends and the light coming from the other end is allowed to fall on a screen(sheet having circular markings) placed perpendicular to the axis of the fiber. Measure the diameter of the laser beam on the screen and the distance between the screen and fiber output end and hence calculate the NA. | | |
| 14 | Determination of the Velocity of Sound in Air. | <ul style="list-style-type: none"> Sound wave of known frequency is generated using a wave generator(WG) and piezo buzzer and are recorded using a microphone(MIC). Phase differences between the WG and MIC waveforms were analyzed in a CRO and the distance between them were adjusted to make both of them in phase and hence calculate velocity of sound. Phase difference can be analyzed from the Lissajous figure obtained by X-Y plotting of WG and MIC waves. ExpEYES may be used. https://expeyes.in/experiments/sound/velocity.html https://expeyes.in/experiments/electrical/xyplot.html | | |
| 15 | Transformation of Energy from One Form to Another. | <ul style="list-style-type: none"> Roll a hollow cylinder from a height, in an inclined plane, without pushing. Measure radius of the cylinder and record the velocity of the cylinder using the gyroscope of the phone inserted into the cylinder. | | |

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| | | <ul style="list-style-type: none"> • Calculate the total energy before the cylinder starts to roll (Potential Energy, mgh) • Calculate the total energy (Translational KE + Rotational KE) when the cylinder reaches the bottom of the plane. • Estimate the energy lost as heat and sound. Repeat the experiment for different heights. • Experiment 23 for Book 4 • https://phyphox.org/experiment/roll/#more-509 | | |
| Books and References: <ol style="list-style-type: none"> 1) A Textbook of Optics by N. Subramanyam, Brij Lal, M N Avadhanulu (25TH EDITION) (Book 1) 2) Optics by Ajoy Ghatak, Tata McGraw-Hill (Book 2) 3) Optics by Eugene Hecht, Addison-Wesley (Book 3) 4) Smartphones as Mobile Minilabs in Physics(Edn. 1) by Jochen Kuhn & Patrik Vogt, Springer, (Book 4) 5) https://phyphox.org/ 6) https://physlets.org/tracker/ | | | | |

Mapping of COs with PSOs and POs :

| | PSO 1 | PSO 2 | PSO 3 | PSO4 | PS O5 | PSO 6 | PO1 | PO2 | PO3 | PO4 | PO5 | PO 6 | PO 7 |
|------|-------|-------|-------|------|-------|-------|-----|-----|-----|-----|-----|------|------|
| CO 1 | 2 | 1 | 0 | 0 | 1 | 1 | 2 | 1 | 0 | 1 | 0 | 1 | 0 |
| CO 2 | 2 | 2 | 1 | 0 | 1 | 1 | 2 | 1 | 0 | 1 | 0 | 1 | 0 |
| CO 3 | 2 | 2 | 2 | 0 | 2 | 2 | 2 | 1 | 0 | 1 | 1 | 1 | 0 |
| CO 4 | 2 | 1 | 1 | 0 | 1 | 1 | 2 | 1 | 0 | 1 | 1 | 1 | 0 |
| CO 5 | 2 | 1 | 1 | 0 | 2 | 2 | 2 | 1 | 0 | 1 | 1 | 1 | 0 |
| CO 6 | 2 | 2 | 1 | 0 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 0 |

Correlation Levels:

| Level | Correlation |
|-------|--------------------|
| 0 | Nil |
| 1 | Slightly / Low |
| 2 | Moderate / Medium |
| 3 | Substantial / High |

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

| | Internal Theory /Practical Exam | Assignment /Viva | Practical Skill Evaluation | End Semester Examinations |
|------|---------------------------------|------------------|----------------------------|---------------------------|
| CO 1 | ✓ | ✓ | | ✓ |
| CO 2 | ✓ | ✓ | | ✓ |
| CO 3 | ✓ | ✓ | | ✓ |
| CO 4 | ✓ | ✓ | | ✓ |
| CO 5 | ✓ | ✓ | | ✓ |
| CO 6 | | ✓ | ✓ | |