

MINOR COURSE- MN 2D	Applied Optics	(Theory Credit -03) (Total Marks=60+15)
--------------------------------	-----------------------	----------------------------------------------------

Course Objective:

1. To introduce students to the fundamental principles of interference, diffraction, and polarization, and their practical applications in optical systems.
2. To provide an understanding of laser physics, including spontaneous and stimulated emissions, laser action, Einstein's coefficients, and the characteristics of different types of lasers.
3. To explore the concept of holography, including the basic theory, types of holograms, and applications in microscopy, interferometry, and character recognition.
4. To study the principles and properties of optical fibers, including light propagation, numerical aperture, and attenuation, with a focus on single-mode and multi-mode fibers.
5. To introduce Fourier optics and optical image processing techniques, including optical filtering and the construction of optical systems like the 4f system for image processing.
6. To examine photonic devices such as LEDs, solar cells, infrared sensors, and optical components, and explore their applications in modern photonics and optical communication systems.

Course Outcomes:

Upon successful completion of the course, students will be able to:

1. Understand and explain the basic principles of interference, diffraction, and polarization, and apply these concepts in optical experiments and technologies.
2. Describe the mechanisms of laser operation, including the processes of spontaneous and stimulated emission, and analyze the characteristics and applications of He-Ne, CO₂, and semiconductor lasers.
3. Understand the theory and practical applications of holography, including the construction and use of different types of holograms in fields like microscopy and interferometry.
4. Analyze the principles of light propagation in optical fibers, calculate the numerical aperture, and understand the attenuation limits and characteristics of single-mode and multi-mode fibers.
5. Apply Fourier optics principles to perform optical image processing tasks such as image addition/subtraction, differentiation, and filtering using optical systems.
6. Demonstrate knowledge of photonic devices such as LEDs, solar cells, IR sensors, and optical components, and understand their roles in modern technologies like optical communication, photovoltaic systems, and photonic crystal devices.

Course Contents:

Introduction (02 HRS): Basics of Interference, Diffraction and Polarization.

Lasers (08 HRS): Spontaneous and stimulated emissions, Theory of laser action, Einstein's coefficients, Light amplification, Characterization of laser beam, three and four level laser system, He-Ne laser, CO₂ laser, Semiconductor lasers, Applications of lasers.

Holography (08 HRS): Basic principle and theory: coherence, resolution, Types of holograms, white light reflection hologram, application of holography in microscopy, Interferometry, and character recognition.

Fiber Optics (10 HRS): Optical fibers and their properties, Principal of light propagation through a fiber, The numerical aperture, Attenuation in optical fiber and attenuation limit, Single mode and multimode fibers.

Fourier optic and image processing (08 HRS): Optical image addition/subtraction, Optical image differentiation, Fourier optical filtering. Construction of an optical 4f system, Fourier Transform Spectroscopy.

Photonic Devices (09 HRS): LED, Solar Cell, Photovoltaic cell, IR Sensors, beam splitters, beam combiner, Mach-Zhender interferometer, optical couplers, Photonic crystals, Meta Materials.

Reference Books:

1. Fundamental of optics, F. A. Jenkins & H. E. White, 1981, Tata McGraw hill.
2. ASERS: Fundamentals & applications, K.Thyagrajan&A.K.Ghatak, 2010, Tata McGraw Hill
3. Fibre optics through experiments, M.R.Shenoy, S.K.Khijwania, et.al. 2009, Viva Books
4. Nonlinear Optics, Robert W. Boyd, (Chapter-I), 2008, Elsevier.
5. Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.
6. Optical Systems and Processes, Joseph Shamir, 2009, PHI Learning Pvt. Ltd.
7. Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.
8. Optical Physics, A.Lipson, S.G.Lipson, H.Lipson, 4 thEdn., 1996, Cambridge Univ. Press

MINOR MN 2D	COURSE-	Applied Optics	(Practical Credit -01) (Total Marks=25)
------------------------	----------------	-----------------------	----------------------------------------------------

1. Experiments on Lasers:

- a) Determination of the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid state laser.
- b) To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser.
- c) To find the polarization angle of laser light using polarizer and analyzer
- d) Thermal expansion of quartz using laser

2. Experiments on Semiconductor Sources and Detectors:

- a) V-I characteristics of LED
- b) Study the characteristics of solid state laser
- c) Study the characteristics of LDR
- d) Photovoltaic Cell
- e) Characteristics of IR sensor

3. Experiments on Holography and interferometry:

- a) Recording and reconstructing holograms.
- b) Constructing a Michelson interferometer or a Fabry Perot interferometer.
- c) Measuring the refractive index of air.
- d) Constructing a Sagnac interferometer.
- e) Constructing a Mach-Zehnder interferometer.
- f) White light Hologram.

4. Experiments on Photonics: Fibre Optics

- a) To measure the numerical aperture of an optical fibre.
- b) To study the variation of the bending loss in a multimode fibre.
- c) To determine the mode field diameter (MFD) of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern.
- d) To measure the near field intensity profile of a fibre and study its refractive index profile.
- e) To determine the power loss at a splice between two multimode fibre.

Research Course-RC (*This course will be offered for those students who opts B.Sc. Honors' with Research.)	Research Methodology	(Credit -04) (Total Marks=75+25) Theory 75 Marks Internal 25 Marks
----------------------------------------------------------------------------------------------------------------------	-----------------------------	---------------------------------------------------------------------------------------------------------

Course Objective:

The course aims to equip students with essential skills in data analysis, research methodology, and scientific writing. It introduces concepts of uncertainties in measurements, probability distributions, and error analysis to enhance precision in experimental and computational research. The course also covers research theory, data collection techniques, statistical analysis, hypothesis testing, and report writing to develop a strong foundation for conducting scientific investigations.

Course Outcomes:

Upon successful completion of the course, students will be able to:

1. Understand and quantify uncertainties in measurements, distinguish between systematic and random errors, and apply significant figures in calculations.
2. Analyze probability distributions, including Binomial, Poisson, Gaussian, and Lorentzian distributions, and apply them to experimental and statistical data.
3. Perform error analysis using statistical and instrumental uncertainty methods, propagate errors, and assess numerical errors in iterative computations.
4. Develop a structured research project by understanding research theory, problem definition, research design principles, and ethical considerations.
5. Apply different data collection methods, measurement techniques, and scaling strategies to ensure accuracy in research.
6. Process and analyze data using statistical tools, including measures of central tendency, dispersion, skewness, regression, and correlation.
7. Conduct hypothesis testing using parametric tests, compare datasets, and evaluate statistical significance in research studies.
8. Develop scientific interpretation skills and write well-structured research reports with proper methodology and critical analysis.

Course Contents:

UNCERTAINTIES IN MEASUREMENTS, PROBABILITY DISTRIBUTIONS, ERROR ANALYSIS (10 HRS): Uncertainties in Measurements: Measuring Errors, accuracy and Precision, systematic errors, Random errors, Significant figures and Round off, Uncertainties, Parent and Sample Distributions, Mean, median and mode, Standard Deviation of Distributions. Probability Distributions: Binomial Distributions, Poisson distribution, Gaussian or Normal Error Distribution, Lorentzian Distribution. Selected problems and examples. Error Analysis: Instrumental and Statistical Uncertainties, Propagation of Errors, Specific Error Formulas withy examples, Application of Error Equations. Numerical Errors, Conditioning and Stability, Convergence of Iterative Processes.

RESEARCH THEORY (08 HRS): Research theory and practice: Research basics, Research theory, Structuring the research project, Research ethics, Finding and reviewing the literature. Defining the Research Problem: Selection of a research Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem: An Illustration. Research Design:

Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs.

DATA COLLECTIONS (08 HRS): Measurement in Research: Measurement Scales, Sources of Error in Measurement, Tests of Sound Measurement, Technique of Developing Measurement Tools. Scaling: Meaning of Scaling, Scale Classification Bases, Important Scaling Techniques, Scale Construction Techniques. Methods of Data Collection: Collection of Primary Data, Observation Method, Collection of Data through Schedules, Some Other Methods of Data Collection.

DATA ANALYSIS (08 HRS): Processing and Analysis of Data: Processing Operations, Some Problems in Processing. Elements/Types of Analysis: Statistics in Research, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), Measures of Relationship, Simple Regression Analysis, Multiple Correlation and Regression, Partial Correlation, Association in Case of Attributes.

HYPOTHESES (06 HRS): Testing of Hypotheses-I (Parametric or Standard Tests of Hypotheses): Basic Concepts Concerning Hypothesis and Testing of Hypotheses, Procedure for Hypothesis Testing, Flow Diagram for Hypothesis Testing, Measuring the Power of a Hypothesis Test, Tests of Hypotheses. Important Parametric Tests, Hypothesis Testing of Means, Hypothesis Testing for Differences between Means, Hypothesis Testing for Comparing Two Related Samples. Hypothesis Testing of Correlation Coefficients, Limitations of the Tests of Hypotheses.

WRITING (05 HRS): Interpretation and Report Writing: Technique of Interpretation, Precaution in Interpretation. Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report Types of Reports, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

Reference Books:

1. Research Methods the Basics by Nicholas Walliaman, Taylor and Francis London& New York 2011.
2. Research Methodology- Methods and Techniques 2nd edition. By C R Kothari, New Age Int. Publ. 2004.
3. Data Reduction and Error Analysis for the Physical Sciences 3rd Ed by Philip R Bevington & D Keith Robinson, McGraw – Hill (2003).
4. Numerical Methods by Balagurusamy, Tata McGraw – Hill (2000).
5. Numerical Analysis, 2nd Ed. by Francis Scheid, McGraw-Hill (2009).