# INTERNATIONAL SCHOOL OF PHOTONICS (ISP)

## COURSE STRUCTURE AND SYLLABI

of

## Master of Science (Five Year Integrated) in Photonics

COCHIN UNIVERSITY OF
SCIENCE AND TECHNOLOGY

KOCHI - 682 022

2024

# MSc in Photonics (Five-Year Integrated)

# Programme Structure (2024 Admission Onwards)

## Vision

To be an Institute of Eminence creating global leaders and innovators in the emerging field of light-based technologies to meet the social challenges of today and the future.

## Mission

- To impart quality education that equip students through rigorous training towards meeting the needs of society and industry.
- To provide state-of-the-art facilities to undertake research activities relevant to light-based industries and promote entrepreneurship.
- To collaborate with premier academic and research institutes around the globe to fortify the education and research environment.

## Program Outcomes: Integrated M.Sc.

PO1: Demonstrate a comprehensive understanding of fundamental principles and concepts in basic sciences.

PO2: Analyze, evaluate, and synthesize complex scientific information and data using appropriate methods and techniques.

PO3: Apply scientific reasoning and critical thinking adeptly to recognize, assess, and resolve problems encountered in various scientific contexts.

PO4: Utilize computational power, programming languages, and modern technologies proficiently to address scientific challenges, effectively integrating technological solutions into problem-solving processes.

PO5: Communicate scientific information effectively and demonstrate proficiency in the use of modern scientific tools and technologies for experimentation, data collection, analysis, and interpretation.

PO6: Adhere to ethical principles and practices in the conduct of scientific research and professional activities, and work collaboratively with others.

PO7: Engage in lifelong learning and professional development to enhance the knowledge and skills in basic sciences.

## Program Specific Outcomes

PSO1: Acquire sufficient knowledge in the areas of mechanics, electronics, electrodynamics, quantum technologies, mathematics, optics, and laser physics.

PSO2: Enhance knowledge in various domains of photonics through specific courses.

PSO3: Foster skills in communication, presentation and scientific writing.

PSO4: Develop proficiency in experimentation, data acquisition and interpretation in advanced topics of physics and optics.

PSO5: Attain knowledge in mathematical tools, modelling and simulations using scientific software packages.

PSO6: Execute projects in advanced topics of photonics to acquire expertise in problem solving skills.

PSO7: Familiarise with modern equipment and complex tools employed in photonics research.

PSO8: Address the societal needs through outreach programmes and extension activities.

## MSc Photonics Scheme (2024 Admission onwards)

| Semester | Number of courses offered by the department | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Major 4 credits** | **Minor 4 credits** | **MDC 3 credits** | **AEC 3 credits** | **SEC 3 credits** | **VAC 3 credits** | **Total credits** |
| I | 1 | 2 | 1 | 2* | | | 21 |
| II | 1 | 2 | 1 | 2* | | | 21 |
| III | 1 | 2 | 1 | | | 2* | 21 |
| IV | 4 | | | | 1 | 1* | 22 |
| V | 5 | | | | 1 | | 23 |
| VI | 5 | | | | 1 | | 23 |
| | | Internship** | | | | | 2 |
| Total credits/courses | 68 (17) | 24 (6)+3 (SEC) | 9 (3) | 12 (4) | 9 (3) | 9 (3) | 133 |
| *Courses offered by the Center for Integrated Studies, CUSAT<br>**Not counted as a course<br>Exit with BSc in Photonics (Total credits = 133) | | | | | | | |
| VII | 4 Courses + seminar/open ended labs/online course (2 credits) | 1 | | | | | 22 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| VIII | 1 Course + seminar/open ended labs/online (2 credits)<br>+ Project (12 credits)<br>Or<br>3 Major Courses + Mini project (4 credits) + seminar/open ended labs/online course ( 2 credits) | 1 | | | | | 22 |
| Total credits/courses | Hon. (Research): 104 (24 + Project)<br>Hon. : 104 (26 + Mini Project) | 32 (8)+3 (SEC) | 9 (3) | 12 (4) | 9 (3) | 9 (3) | 177 |
| Exit with BSc (Honours with Research) in Photonics (Total credits = 177)<br>Exit with BSc (Honours) in Photonics (Total credits = 177) | | | | | | | |
| IX | 5 Courses + online (2 credit**) | | | | | | 20-24 |
| X | Major project + online (2 credit**) | | | | | | 20-24 |
| Total credits | 148 | 32 (8)+3 (SEC) | 9 (3) | 12 (4) | 9 (3) | 9 (3) | 221 |
| ** Instead of taking two online courses worth 2 credits each, a student can opt for one online course worth 4 credits in the ninth/tenth semester. In such cases, the credits earned in that semester will be 24, and in the other semester, they will be 20.<br>Exit with MSc in Photonics (Total credits = 221) | | | | | | | |

MDC: Multi-Disciplinary Courses
AEC: Ability Enhancement Courses
SEC: Skill enhancement Courses
VAC: Value Added Courses

## Academic pathways offered by International School of Photonics

### Photonics Major:

3-year UG Program: To earn a Photonics Major in a 3-year UG Program, a student must complete a minimum of 68 credits in Photonics, out of which 60 credits shall be from DSC courses and 8 credits from DSE courses.

4-year UG Program (Honours): To earn a Photonics Major in a 4-year UG Program (Honours), a student must complete a minimum of 104 credits in Photonics, out of which 84 credits (including 4 credits from a research project) shall be from DSC courses and 20 credits from DSE courses.

4-year UG Program (Honours with Research): To earn a Photonics Major in a 4-year UG Program (Honours with Research), a student must complete a minimum of 104 credits in Photonics, out of which 88 credits (including 12 credits from a research project) shall be from DSC courses and 16 credits from DSE courses.

5-Year Integrated MSc in Photonics: To earn a 5-Year Integrated MSc in Photonics, a student must complete a minimum of 148 credits in Photonics including 20 credits from a major project.

### Photonics Minor:

3-year UG Program: To earn a Minor in Photonics in a 3-year UG Program, a student must complete a minimum of 27 credits in Photonics, out of which 24 credits shall be from DSC courses and 3 credits from an SEC elective.

4-year UG Program: To earn a Minor in Photonics in a 4-year UG Program, a student must complete a minimum of 35 credits in Photonics, out of which 24 credits shall be from DSC courses and 3 credits from an SEC elective 8 credits from DSE courses.

### Discipline mention in Photonics:

To earn a Discipline mention in Photonics in a UG Program (3 or 4 years), a student must complete a minimum of 12 credits in Photonics from DSC courses.

### Lateral entry

Lateral entry to the 7th semester shall be permitted for students who have successfully completed BSc in Photonics subject to the availability of seats, as per the rules and regulations of the University.

Lateral entry to the 9th semester shall be permitted for students who have successfully completed BSc (Honours)/ BSc (Honours with Research) in Photonics subject to the availability of seats, as per the rules and regulations of the University.

## Scheme

## Semester I

| Course Code | Course Name | Level | The course can be taken towards obtaining credits for: | Credits | Hours/ week L-T-P | Marks distribution | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | CA | ESE | Total |
| 24-812-0101 | Optics I: Geometrical and Physical Optics | 100 | Photonics Major -DSC, Photonics Minor-DSC, Photonics Disci-DSC | 4 | 3-0-2 | 50 | 50 | 100 |
| 24-812-0102 | Introduction to Photonics | 100 | Photonics Minor-DSC, Photonics Disci-DSC | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-0103 | General Optics | 100 | MDC | 3 | 3-0-0 | 50 | 50 | 100 |
| Semester Credits for Photonics Major | 21 (AEC: 6, MDC: 3, Major pathway: 4, Minor pathway: 8) Cumulative credits: 21 | | | | | | | |

L: Lecture, T: Tutorial, P: Practicum

Photonics Major-DSC: Core course for students Majoring in Photonics.

Photonics Minor-DSC: Core course for students Minoring in Photonics.

Photonics Disci-DSC: Core course for students who choose discipline mention in Photonics.

Photonics-MDC: Multidisciplinary elective course offered to students whose Major or Minor pathways are different from Photonics.

AEC: Ability Enhancement Course (Languages).

MDC: Multidisciplinary Course.

## Semester II

| Course Code | Course Name | Level | The course can be taken towards obtaining credits for: | Credits | Hours/ week L-T-P | Marks distribution | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | CA | ESE | Total |
| 24-812-0201 | Mathematical Physics I | 100 | Photonics Major -DSC, Photonics Minor-DSC, Photonics Disci-DSC | 4 | 3-0-2 | 50 | 50 | 100 |
| 24-812-0202 | Applied Optics | 100 | Photonics Minor-DSC, Photonics Disci-DSC | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-0203 | Mathematical Methods | 100 | Photonics MDC | 3 | 3-0-0 | 50 | 50 | 100 |
| Semester Credits for Photonics Major | 21 (AEC: 6, MDC: 3, Major pathway: 4, Minor pathway: 8) Cumulative credits: 42 | | | | | | | |

## Semester III

| Course Code | Course Name | Level | The course can be taken towards obtaining credits for: | Credits | Hours/ week L-T-P | Marks distribution | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | CA | ESE | Total |
| 24-812-0301 | Mechanics | 200 | Photonics Major -DSC, Photonics Minor-DSC, Photonics Disci-DSC | 4 | 3-0-2 | 50 | 50 | 100 |
| 24-812-0302 | Nano-Bio photonics | 200 | Photonics Minor-DSC, Photonics Disci-DSC | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-0303 | Basic Mechanics | 200 | Photonics MDC | 3 | 3-0-0 | 50 | 50 | 100 |
| Semester Credits for Photonics Major | 21 (VAC: 6, MDC: 3, Major pathway: 4, Minor pathway: 8) Cumulative credits: 63 | | | | | | | |

## Semester IV

| Course Code | Course Name | Level | The course can be taken towards obtaining credits for: | Credits | Hours/ week L-T-P | Marks distribution | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | CA | ESE | Total |
| 24-812-0401 | Thermal and Statistical Physics | 200 | Photonics Major -DSC | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-0402 | Mathematical physics II | 200 | Photonics Major -DSC | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-0403 | Electronics | 200 | Photonics Major -DSC | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-0404 | Quantum mechanics I | 200 | Photonics Major -DSC | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-0405 | General Photonics Lab | 200 | Photonics Major SEC, Photonics Minor-SEC, | 3 | 0-0-6 | 100 | | 100 |
| Semester Credits for Photonics Major | 22 (VAC: 3, SEC: 3, Major pathway: 16) Cumulative credits: 85 | | | | | | | |

## Semester V

| Course Code | Course Name | Level | The course can be taken towards obtaining credits for: | Credits | Hours/ week L-T-P | Marks distribution | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | CA | ESE | Total |
| 24-812-0501 | Quantum Mechanics II | 300 | Photonics Major -DSC | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-0502 | Electrodynamics | 300 | Photonics Major -DSC | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-0503 | Spectroscopy | 300 | Photonics Major -DSC, Photonics Minor-DSC, Photonics Disci-DSC | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-0504 | Optics II: Applied Optics | 300 | Photonics Major -DSC | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-0505 | Elective I: MOOC* | 300 | Photonics Major -DSE | 4 | 4-0-0 | | 100 | 100 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 24-812-0506 | General Physics Lab | 300 | Photonics Major -SEC | 3 | 0-0-6 | 100 | | 100 |
| Semester Credits for Photonics Major | 23 (SEC: 3, Major pathway: 20)<br>Cumulative credits: 108 | | | | | | | |

* 24-812-0505 MOOC (1 course of 4 credits/2courses of 2 credits)

## Semester VI

| **Course Code** | **Course Name** | **Level** | **The course can be taken towards obtaining credits for:** | **Credits** | **Hours/ week**<br>**L-T-P** | **Marks distribution** | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | **CA** | **ESE** | **Total** |
| 24-812-0601 | Laser Physics | 300 | Photonics Major -DSC | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-0602 | Fiber Optics | 300 | Photonics Major -DSC<br>Photonics Minor-DSC,<br>Photonics Disci-DSC | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-0603 | Computational Methods in Optics and Photonics | 300 | Photonics Major -DSC | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-0604 | Optical Instrumentation | 300 | Photonics Major -DSC | 4 | 3-0-2 | 50 | 50 | 100 |
| 24-812-060X | Elective II | 300 | Photonics Major -DSE | 4 | 3-0-2 | 50 | 50 | 100 |
| 24-812-0605 | Computational Lab | 300 | Photonics Major -SEC | 3 | 0-0-6 | 100 | | 100 |
| Semester Credits for Photonics Major | 23 (SEC: 3, Major pathway: 20)<br>Cumulative credits: 131 | | | | | | | |

**List of Electives II**

24-812-0606 Optical Sensor Technology

24-812-0607 Photonic Crystals and Optical Metamaterials

24-812-0608 Fourier Optics & Optical Signal Processing

**Internship**

Students have to complete an internship of 2 credits (60 Hours of work) before the beginning of Semester VII.
Cumulative Credits: 133

Exit with 3-year UG Degree OR continue to the 4$^{th}$ year.

Semester VII

| Course Code | Course Name | Level | The course can be taken towards obtaining credits for: | Credits | Hours/ week L-T-P-S | Marks distribution | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | CA | ESE | Total |
| 24-812-0701 | Optoelectronics | 400 | Photonics Major -DSC, Photonics Minor-DSE, Photonics Disci-DSC | 4 | 3-0-2 | 50 | 50 | 100 |
| 24-812-0702 | Condensed Matter Physics | 400 | Photonics Major -DSC | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-0703 | Photonics Lab 1 and Seminar | 400 | Photonics Major -DSC | 4 | 0-0-6-1 | 100 +50 | | 100+ 50 |
| 24-812-0704 | Open ended lab | 400 | Photonics Major -DSC | 2 | 0-0-4 | 50 | | 50 |
| 24-812-070X | Elective III | 400 | Photonics Major -DSE Photonics Minor-DSE, Photonics Disci-DSC | 4 | 4-0-0 | 50 | 50 | 100 |
| Semester Credits for Photonics Major | 22 (Major pathway: 18, Minor pathway 4)<br>Cumulative credits: 155 | | | | | | | |

S: Seminar

**List of Electives III**

24-812-0705 Non-Linear Optics

24-812-0706 Nanophotonics

24-812-0707 Laser spectroscopy

24-812-0708 Quantum Optics & Quantum Computing

24-812-0709 Advanced Electromagnetic Theory

## Semester VIII

For Honours with Research

| Course Code | Course Name | Level | The course can be taken towards obtaining credits for: | Credits | Hours/ week L-T-P-S | Marks distribution | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | CA | ESE | Total |
| 24-812-0801 | Elective IV: MOOC II | 400 | Photonics Major -DSE | 4 | | | 100 | 100 |
| 24-812-0802 | Project | 400 | Photonics Major -DSC | 12 | 0-0-24 | 300 | | 300 |
| 24-812-0803 | Seminar | 400 | Photonics Major -DSC | 2 | 0-0-0-2 | 100 | | 100 |
| Semester Credits for Photonics Major | 22 (Major pathway: 18, Minor pathway 4)<br>Cumulative credits: 177 | | | | | | | |

For Honours

| Course Code | Course Name | Level | The course can be taken towards obtaining credits for: | Credits | Hours/ week L-T-P-S | Marks distribution | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | CA | ESE | Total |
| 24-812-0804 | Mini Project | 400 | Photonics Major -DSC | 4 | 0-0-8 | 100 | | 100 |
| 24-812-0805 | Photonics lab 1 | 400 | Photonics Major -DSC | 4 | 0-0-8 | 100 | | 100 |
| 24-812-0801 | Elective IV: MOOC II | 400 | Photonics Major -DSE | 4 | 4-0-0 | | 100 | 100 |
| 24-812-0803 | Seminar | 400 | Photonics Major -DSC | 2 | 0-0-0-2 | 100 | | 100 |
| 24-812-080X | Elective V | 400 | Photonics Major -DSE, Photonics Minor-DSE, Photonics Disci-DSC | 4 | 3-0-2 | 50 | 50 | 100 |
| Semester Credits for Photonics Major | 22 (Major pathway: 18, Minor pathway 4)<br>Cumulative credits: 177 | | | | | | | |

**List of Electives IV**

MOOC courses preferably on Optical Communication or Solar Cells

**List of Electives V**

24-812-0806 Optomechanical Engineering

24-812-0807 Laser Systems and Laser Applications

24-812-0808 Biophotonics

Exit with 4-year UG Degree OR continue to the 5th year.

## Semester IX

| Course Code | Course Name | Level | The course can be taken towards obtaining credits for: | Credits | Hours/ week L-T-P | Marks distribution | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | CA | ESE | Total |
| 24-812-0901 | Industrial Photonics | 500 | Photonics Major -DSC | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-0902 | Photonics lab 2 | 500 | Photonics Major -DSC | 4 | 0-0-8 | 100 | | 100 |
| 24-812-0903 | Elective VI: MOOC III** | 500 | Photonics Major -DSE | 2 | | | 100 | 100 |
| 24-812-090X | Elective VII | 500 | Photonics Major -DSE, Photonics Minor-DSE | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-090X | Elective VIII | 500 | Photonics Major -DSE, Photonics Minor-DSE | 4 | 4-0-0 | 50 | 50 | 100 |
| 24-812-090X | Elective IX | 500 | Photonics Major -DSE | 4 | 4-0-0 | 50 | 50 | 100 |
| Semester Credits for Photonics Major | 22 (Major pathway: 22)<br>Cumulative credits: 199 | | | | | | | |

**List of Electives VII-IX**

24-812-0904 Quantum Communications

24-812-0905 Ultrafast Photonics

24-812-0906 Plasma Physics

24-812-0907 Microscopic Techniques

## Semester X

| Course Code | Course Name | Level | The course can be taken towards obtaining credits for: | Credits | Hours/ week L-T-P | Marks distribution | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | CA | ESE | Total |
| 24-812-1001 | Major Project | 600 | Photonics Major -DSC | 20 | 0-0-40 | 600 | | 600 |
| 24-812-1002 | Elective X: MOOC IV** | 500 | Photonics Major -DSE | 2 | | | 100 | 100 |
| Semester Credits for Photonics Major | 22 (Major pathway: 22)<br>Cumulative credits: 221 | | | | | | | |

**Instead of taking the online course worth 2 credits, a student has the option to select one online course worth 4 credits in the ninth/tenth semester. In such cases, the credits earned in that semester will total 24. Consequently, they won't need to enrol in the MOOC course in the other semester, and the maximum credits for that semester will be 20.

**Question paper pattern for end semester examination**

The following Question paper pattern will be followed for semester end assessment.

Section I

Short answer questions 6 out of 6 (3 marks x 6 =18 marks). No choices will be provided in this section. at least one question from each module should be asked. Additional 2 questions may be asked from modules with more teaching hours.

Section II

1 out of 2 from each module (8 marks x 4 =32 marks)

**Detailed Syllabus**

**23-812-0101 Optics I: Geometrical and Physical Optics**
**(Level 100)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand the concept of radiometry and photometry. | Understand | 5 | 4 |
| CO2 | Explain the principles of colourimetry, chromaticity coordinates and human colour vision. | Understand | 6 | 4 |
| CO3 | Apply matrix methods in optics. | Apply | 6 | 2 |
| CO4 | Interpret various types of aberration and dispersion phenomena in optical system | Apply | 6 | 4 |
| CO5 | Explain the interference phenomena by division of wavefront and division of amplitude. | Understand | 5 | 4 |
| CO6 | Describe the concept of coherence and superposition in optics | Understand | 6 | 4 |
| CO7 | Analyse the principles of thin film interference. | Apply | 5 | 4 |
| CO8 | Analyse various systems based on the principle of interference. | Apply | 6 | 4 |
| | Total Number of Hours | | 45 | 30 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 |
|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 1 | 3 | | | |
| CO2 | 3 | 1 | 1 | 3 | | | |
| CO3 | 3 | 1 | 1 | 3 | | | |
| CO4 | 3 | 1 | 1 | 3 | | | |
| CO5 | 3 | 1 | 1 | 3 | | | |
| CO6 | 3 | 1 | 1 | 3 | | | |
| CO7 | 3 | 1 | 1 | 3 | | | |
| CO8 | 3 | 1 | 1 | 3 | | | |

3-High; 2-Medium; 1-Low

Module I

Photometry and Radiometry- quantities and units, Colourimetry- chromaticity coordinates, UCS chromaticity coordinates, UCS diagrams, RGB colour mixing and colour purity, colour temperature, CCT, Visual basis of colourimetry, Human eye and colour deficiency, colour vision model.

Module II

Optical path, Fermat's principle, Dispersion- normal and anomalous dispersion, Wood's experiment, achromatism in prisms, dispersion without deviation.

Aberrations- Spherical aberration, coma, astigmatism, distortion, chromatic aberration.

Matrix methods in Optics- Paraxial rays, Matrix representation of translation, refraction, reflection of light rays, ABCD law, lens waveguide.

Module III

Superposition of two sinusoidal waves, path difference and phase difference, Analytical and graphical methods. Coherent sources, spatial and temporal coherence, complex representation of light waves, Interference of two monochromatic waves, optical beats.
Theory of interference and bandwidth, Interference by division of wave front, Young's double slit experiment, Fresnel's bi-prism, Lloyd's mirrors.

Module IV
Interference by division of amplitude, two beam interference, parallel sided plates, colour of thin films, wedge shaped film, Haidinger and Fizeau fringes, Newton's rings - reflected and transmitted systems, Radius of rings and expression for wavelength, Michelson interferometer, Determination of wavelength separation and standardization of meter. Types of fringes- localized and non-localised fringes in white light.

**Reference**


1. Optics, Ajoy Ghatak, 7th Edition,Tata McGraw Hill, ( 2020) (Text)
2. A Textbook of Optics, N Subrahmaniam and Brij Lal, M N Avadhanulu, S Chand and
3. Company, 23rd Edition, (2006) (Text)
4. Handbook of Applied Photometry, C De Cusatis, AIP. (1997) (Text)
5. Light emitting diodes- E Fred Scheubert, Cambridge University Press (2006)
6. Modern Optics, A B Gupta, Books & Allied Ltd; 4th Revised edition (2013)
7. Optics, Eugene Hecht and A R Ganesan, 5th Edition, Pearson Education (2017)
8. Fundamentals of Optics, Jenkins and White, McGraw Hill Education, 4th edition (2017)
9. Wave optics and applications, R.S Sirohi, Orient Longman, (1993)

**24-812- 0102 Introduction to Photonics**

**(Level 100)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand the basic properties of photons and how photons interact with atoms. | Understand | 7 | 0 |
| CO2 | Understand the concept of photonics, its application and recent advancement in the field of photonics. | Understand | 8 | 0 |
| CO3 | Understand the concept of LASER and lasing action, spectral width and gain of the laser. | Understand | 6 | 0 |
| CO4 | Understand the different types of LASER and its application in the field of photonics. | Understand | 9 | 0 |
| CO5 | Understand the history and basic concept of light propagation through the optical fiber. | Understand | 7 | 0 |
| CO6 | Understand the construction of optical fiber, its types, transmission characteristics and fundamentals of communication system. | Understand | 7 | 0 |
| CO7 | Understand the basics and principles of holography and its recording and reconstruction. | Understand | 8 | 0 |
| CO8 | Understand the difference between holography and ordinary photography and its application in the current scenario. | Understand | 8 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | | | | | |
| CO2 | 3 | 3 | 1 | | | | | |
| CO3 | 3 | 3 | 1 | | | | | |
| CO4 | 3 | 3 | 1 | | | | | |
| CO5 | 3 | 3 | 1 | | | | | |
| CO6 | 3 | 3 | 1 | | | | | |
| CO7 | 3 | 3 | 1 | | | | | |
| CO8 | 3 | 3 | 1 | | | | | |

3-High; 2-Medium; 1-Low

Module I

Photon, properties of photon, Interaction of photons with atoms: energy loss mechanisms- photoelectric effect, Compton scattering, pair production, linear attenuation coefficient, mass attenuation coefficient.

Introduction to photonics, applications of photonics, recent advancement in the field of photonics.

Module II

LED and LASER, advantages of LASER over LED, spontaneous and stimulated emissions, Einstein coefficients, rates of stimulated emission and absorption, condition for amplification by stimulated

emission, meta-stable state and lasing action, spectral width of LASER, gain for self-sustained oscillations in the lasing cavity, LASER rate equation.
Examples of types of lasers: fiber laser, gas laser, tunable lasers: semiconductor lasers, Applications of lasers.

Module III
Introduction to optical fibre, historical development in the field of optical fibre, advantages, disadvantages, and applications of optical fibre communication, principle of light propagation in optical fibre, optical fibre fabrication, types of optical fibres: single mode and multimode fibres.
Transmission characteristics of optical fibre: attenuation, absorption, scattering losses, bending loss, dispersion, intra modal dispersion, inter modal dispersion.
Fundamentals of optical fiber communication systems.

Module IV
Holography-hologram, basic principle of holography, principle of hologram construction, construction of a hologram, recording and reconstruction of the image, comparison with ordinary photography, applications of hologram.

**References**


1. Photonics: Elements and Devices, V V Rampal, Wheeler, Delhi, 1992.
2. Introducing Photonics, Brian Culshaw, University of Strathclyde, Cambridge University press, 2020.
3. Fundamentals of Photonics, Bahaa E. A. Saleh, Malvin Carl Teich, Wiley, 1991.
4. Lasers: Fundamentals and Applications, K. Thyagarajan, Ajoy Ghatak, Springer New York, NY, 2010, 2nd edition.
5. An Introduction to Fiber Optics, Ajoy K. Ghatak, K. Thyagarajan, Cambridge University Press, 2012.
6. Three-dimensional holographic imaging, Chung J. Kuo, Meng Hua Tsai, John Wiley & Sons, 2002,

**24-812-0103 General Optics**

**(Level 100)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand the concept of radiometry and photometry. | Understand | 5 | 0 |
| CO2 | Explain the principles of colourimetry, chromaticity coordinates and human colour vision. | Understand | 6 | 0 |
| CO3 | Apply matrix methods in optics. | Apply | 6 | 0 |
| CO4 | Interpret various types of aberration and dispersion phenomena in optical system | Apply | 6 | 0 |
| CO5 | Explain the interference phenomena by division of wavefront and division of amplitude. | Understand | 5 | 0 |
| CO6 | Describe the concept of coherence and superposition in optics | Understand | 6 | 0 |
| CO7 | Analyse the principles of thin film interference. | Apply | 5 | 0 |
| CO8 | Analyse various systems based on the principle of interference. | Apply | 6 | 0 |
| | Total Number of Hours | | 45 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 |
|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 1 | 3 | | | |
| CO2 | 3 | 1 | 1 | 3 | | | |
| CO3 | 3 | 1 | 1 | 3 | | | |
| CO4 | 3 | 1 | 1 | 3 | | | |
| CO5 | 3 | 1 | 1 | 3 | | | |
| CO6 | 3 | 1 | 1 | 3 | | | |
| CO7 | 3 | 1 | 1 | 3 | | | |
| CO8 | 3 | 1 | 1 | 3 | | | |

3-High; 2-Medium; 1-Low

Module I

Photometry and Radiometry- quantities and units, Colourimetry- chromaticity coordinates, UCS chromaticity coordinates, UCS diagrams, RGB colour mixing and colour purity, colour temperature, CCT, Visual basis of colourimetry, Human eye and colour deficiency, colour vision model.

Module II

Optical path, Fermat's principle, Dispersion- normal and anomalous dispersion, Wood's experiment, achromatism in prisms, dispersion without deviation.

Aberrations- Spherical aberration, coma, astigmatism, distortion, chromatic aberration.

Matrix methods in Optics- Paraxial rays, Matrix representation of translation, refraction, reflection of light rays, ABCD law, lens waveguide.

Module III

Superposition of two sinusoidal waves, path difference and phase difference, Analytical and graphical methods. Coherent sources, spatial and temporal coherence, complex representation of light waves, Interference of two monochromatic waves, optical beats.
Theory of interference and bandwidth, Interference by division of wave front, Young's double slit experiment, Fresnel's bi-prism, Lloyd's mirrors.

Module IV
Interference by division of amplitude, two beam interference, parallel sided plates, colour of thin films, wedge shaped film, Haidinger and Fizeau fringes, Newton's rings - reflected and transmitted systems, Radius of rings and expression for wavelength, Michelson interferometer, Determination of wavelength separation and standardization of meter. Types of fringes- localized and non-localised fringes in white light.

**Reference**


1. Optics, Ajoy Ghatak, 7th Edition,Tata McGraw Hill, ( 2020) (Text).
2. A Textbook of Optics, N Subrahmaniam and Brij Lal, M N Avadhanulu, S Chand and
3. Company, 23rd Edition, (2006) (Text).
4. Handbook of Applied Photometry, C De Cusatis, AIP. (1997) (Text).
5. Light emitting diodes- E Fred Scheubert, Cambridge University Press (2006).
6. Modern Optics, A B Gupta, Books & Allied Ltd; 4th Revised edition (2013).
7. Optics, Eugene Hecht and A R Ganesan, 5th Edition, Pearson Education (2017).
8. Fundamentals of Optics, Jenkins and White, McGraw Hill Education, 4th edition (2017).
9. Wave optics and applications, R.S Sirohi, Orient Longman, (1993)

**24-812-0201 Mathematical Physics I**

**(Level 100)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand the concepts of vector calculus and matrices. | Understand | 8 | 0 |
| CO2 | Utilize vector calculus, matrix inversion and fundamental theorems of vector calculus to interpret physical phenomena effectively. | Apply | 8 | 0 |
| CO3 | Understand differentiation of hyperbolic and inverse hyperbolic functions, and the application of Taylor's and McLaurin's theorems. | Understand | 8 | 0 |
| CO4 | Apply numerical techniques for integration, integration, polynomial fitting and interpolation. | Apply | 6 | 0 |
| CO5 | Understand curvilinear coordinates. | Understand | 8 | 0 |
| CO6 | Apply curvilinear coordinates for effectively representing mathematical operations like integrations and differentiations. | Apply | 8 | 0 |
| CO7 | Understand first order equations and partial differential equations. | Understand | 8 | 0 |
| CO8 | Apply numerical methods for solving differential equations. | Apply | 6 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO2 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO3 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO4 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO5 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO6 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO7 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO8 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |

3-High; 2-Medium; 1-Low

Module I

Vector calculus: vector differentiation, gradient, divergence and curl, solenoidal and irrotational vector point functions. Vector integration, line, surface and volume integration, Green's theorem, Gauss theorem and Stokes theorem, physical interpretations.

Matrices: orthogonal, symmetric, skew symmetric, Hermitian and skew Hermitian matrices, elementary transformations of a matrix. Similarity and unitary transformation of matrices, diagonalization of matrices, Eigenvalues and eigenvectors, Cayley-Hamilton theorem, solution of algebraic equations using matrices, consistent and inconsistent equations.

Module II

Differential calculus: differentiation of hyperbolic and inverse hyperbolic functions. Taylor's and Mclaurin's theorems, Application to expansion functions.

Partial differentiation: partial derivatives and total differential coefficients. Euler's theorem on homogeneous function, chain rule for partial derivatives, errors and approximations.

Numerical differentiation: first and second order derivatives.

Integral calculus: numerical integration: trapezoidal, Simpson's and Gaussian quadrature methods.

Least-square curve fitting: straight line and polynomial fits, Interpolation: Newton's and Lagrange's formulas

Module III

Curvilinear coordinates: description of curvilinear coordinate system, expression for square of distance element, metric-scale factors, differential distance vector, line integral, area element and area vector, volume element and volume integral, conversion of unit vectors in spherical and cylindrical coordinates into rectangular coordinates and vice versa.

Gradient, divergence, curl and Laplacian operators in curvilinear coordinate systems.

Module IV

Ordinary differential equations: first order equation, variables separable, homogeneous and non-homogeneous equations, integrating factor, Bernoulli's equations, enact equations, second order linear differential equations with constant coefficients. Complementary function and particular integrals, solution using auxiliary equation.

Numerical solutions of ordinary differential equations: Euler's method and Runge-Kutta methods.

Partial differential equations: derivation of PDE by elimination of arbitrary constants and arbitrary coefficients. Concept of Jacobian. Solution of Lagrange's differential equations, Partial differential equation of the second degree, Laplace, Helmholtz and Poisson equations.

**References**


1. Mathematical Methods for Physicists G. B. Arfken and H. J. Weber, Academic Press, 2001 (Text).
2. Mathematical Methods in the Physical Sciences, 3rd. Ed., M. L. Boas, John Wiley, 2005 (Text).
3. Advanced Engineering Mathematics - 10th Ed., Erwin Keryszig, Wiley, 2011 (Text).
4. Mathematical Methods for Physics and Engineering - 3rd Ed., K. F. Riley, M. P. Hobson and S. J. Bence, Cambridge University Press, 2006 (Text).
5. Vector Analysis with an Introduction to Tensor Analysis - Murray R Spiegel, Tata McGraw Hill (1975) Schaum Series (Text).
6. Differential Equations, Richard Bronson, Tata McGraw Hill, New Delhi, 1994 (Text).
7. Differential Equations and Linear Algebra, Stephen W. Goode and Scott A. Annin, Pearson, 2005 (Text)
8. Advanced Mathematics for Engineers Scientists, Murray R Spiegel, McGraw-Hill Education, 2009 (Text).
9. Matrices and Tensors for Physicists, A W Joshi, New Age International (1995)
10. Numerical Methods - Balagurusamy, Tata McGraw Hill, 2001 (Text).
11. Introductory Methods of Numerical Analysis, 5th Ed., S. S. Sastry, Prentice Hall of India, 2012 (Text).
12. Differential Equations - 3rd Ed., Shepley L. Ross, Wiley. 2007 (Text).
13. Introduction to Mathematical Physics, Harper Lee and Charlie Mackesy, Prentice Hall India, 1978.

**24-812-0202 Applied Optics**

**(Level 100)**

| CO | CO statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Explain the basic concepts of diffraction, including Fresnel's assumptions and rectilinear propagation of light. | Understand | 8 | 0 |
| CO2 | Apply the Fresnel-Kirchhoff integral and Fourier transform in analysing Fraunhofer and Fresnel diffractions. | Apply | 7 | 0 |
| CO3 | Compare and contrast different types of gratings, including blazed gratings. | Analyse | 7 | 0 |
| CO4 | Analyse the resolution and dispersive power of spectrographs and monochromators based on grating properties. | Analyse | 8 | 0 |
| CO5 | Describe the mathematical description of polarization and different states of polarization. | Understand | 7 | 0 |
| CO6 | Analyse the properties of polarizers, wave plates, birefringent crystals, and circular polarizers. | Analyse | 8 | 0 |
| CO7 | Identify dextro and levo rotatory substances and explain their optical activity. | Understand | 7 | 0 |
| CO8 | Apply Jones and Muller matrix calculus to analyse polarizers, retarders, and rotators. | Apply | 8 | 0 |
| | Total number of hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 |
|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 1 | 3 | | | |
| CO2 | 3 | 1 | 1 | 3 | | | |
| CO3 | 3 | 1 | 1 | 3 | | | |
| CO4 | 3 | 1 | 1 | 3 | | | |
| CO5 | 3 | 1 | 1 | 3 | | | |
| CO6 | 3 | 1 | 1 | 3 | | | |
| CO7 | 3 | 1 | 1 | 3 | | | |
| CO8 | 3 | 1 | 1 | 3 | | | |

3-High; 2-Medium; 1-Low

Module I

Diffraction-Fresnel's assumptions, rectilinear propagation of light and Fresnel's theory, Fresnel's zones, theory of zone plate, Fraunhofer and Fresnel diffractions, Fresnel-Kirchhoff integral, Fourier transform in Fraunhofer diffraction, diffraction by a single slit, diffraction by a rectangular and circular aperture, limit of resolution, Fourier transforming property of lens, spatial frequency filtering

Module II

Diffraction grating, resolution of a grating, types of gratings, blazed gratings, Mountings for gratings- various mounting techniques, Grating spectrographs, resolution and dispersive power of spectrographs, single beam and double beam monochromators. Spectrometers and fluorimeters

Module III

Analysis of Polarization- Mathematical description of polarization, states of polarization, polarization ellipse, special forms, Elliptical parameters,

Double refraction, ordinary and extraordinary rays, Optical Anisotropy-Index ellipsoid, Nicol prism, Nicol prism as a polarizer. Wave plates, full wave plate, Quarter wave and Half wave plates, Birefringence-Birefringent crystals, polarisers, polarization beam splitters, Compensators and Variable retarders, Circular polarizers,

Module IV

Optical activity - Dextro and levo rotatory substances, optical activity in liquids, Half-shade plate, Laurent's half-shade polarimeter, Stress birefringence – Photoelasticity

Jones and Muller matrix calculus- Matrices for polarizer, retarder, and rotator in both representations, Neutral density filter, Muller matrix for Depolarizer

Stokes polarization parameters, Stokes vectors, Stokes parameters for polarized and unpolarized light, Stokes Intensity formula, Poincare sphere, Representation of polarization states

**References**


1. Optics, Eugene Hecht and A R Ganesan, 5th Edition, Pearson Education (2017).
2. Optics- Ajoy Ghatak, McGraw Hill (2020).
3. Polarized light – Edward Collet, Marcel Decker (1992).
4. Introduction to Optoelectronics- Wilson and Hawkes, PHI, (1996).
5. Wave optics and Applications - R. S. Sirohi, Orient Longmann (2001).
6. Optical Electronics - Thyagarajan and Ghatak, Cambridge India (2017).
7. Polarization of light - S. Huard, Wiley (1997).

**24-812-0203 Mathematical Methods**

**(Level 100)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand the concepts of vector calculus and matrices. | Understand | 5 | 0 |
| CO2 | Utilize vector calculus, matrix inversion and fundamental theorems of vector calculus to interpret physical phenomena effectively. | Apply | 5 | 0 |
| CO3 | Understand differentiation of hyperbolic and inverse hyperbolic functions, and the application of Taylor's and McLaurin's theorems. | Understand | 5 | 0 |
| CO4 | Apply numerical techniques for integration, integration, polynomial fitting and interpolation. | Apply | 6 | 0 |
| CO5 | Understand curvilinear coordinates. | Understand | 6 | 0 |
| CO6 | Apply curvilinear coordinates for effectively representing mathematical operations like integrations and differentiations. | Apply | 6 | 0 |
| CO7 | Understand first order equations and partial differential equations. | Understand | 6 | 0 |
| CO8 | Apply numerical methods for solving differential equations. | Apply | 6 | 0 |
| | Total Number of Hours | | 45 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO2 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO3 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO4 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO5 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO6 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO7 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO8 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |

3-High; 2-Medium; 1-Low

Module I

Vector calculus: vector differentiation, gradient, divergence and curl, solenoidal and irrotational vector point functions. Vector integration, line, surface and volume integration, Green's theorem, Gauss theorem and Stokes theorem, physical interpretations.

Matrices: orthogonal, symmetric, skew symmetric, Hermitian and skew Hermitian matrices, elementary transformations of a matrix. Similarity and unitary transformation of matrices, diagonalization of matrices, Eigenvalues and eigenvectors, Cayley-Hamilton theorem, solution of algebraic equations using matrices, consistent and inconsistent equations.

Module II

Differential calculus: differentiation of hyperbolic and inverse hyperbolic functions. Taylor's and Mclaurin's theorems, Application to expansion functions.

Partial differentiation: partial derivatives and total differential coefficients. Euler's theorem on homogeneous function, chain rule for partial derivatives, errors and approximations.

Numerical differentiation: first and second order derivatives.

Integral calculus: numerical integration: trapezoidal, Simpson's and Gaussian quadrature methods.

Least-square curve fitting: straight line and polynomial fits, Interpolation: Newton's and Lagrange's formulas

Module III

Curvilinear coordinates: description of curvilinear coordinate system, expression for square of distance element, metric-scale factors, differential distance vector, line integral, area element and area vector, volume element and volume integral, conversion of unit vectors in spherical and cylindrical coordinates into rectangular coordinates and vice versa.

Gradient, divergence, curl and Laplacian operators in curvilinear coordinate systems.

Module IV

Ordinary differential equations: first order equation, variables separable, homogeneous and non-homogeneous equations, integrating factor, Bernoulli's equations, enact equations, second order linear differential equations with constant coefficients. Complementary function and particular integrals, solution using auxiliary equation.

Numerical solutions of ordinary differential equations: Euler's method and Runge-Kutta methods.

Partial differential equations: derivation of PDE by elimination of arbitrary constants and arbitrary coefficients. Concept of Jacobian. Solution of Lagrange's differential equations, Partial differential equation of the second degree, Laplace, Helmholtz and Poisson equations.

**References**


1. Mathematical Methods for Physicists G. B. Arfken and H. J. Weber, Academic Press, 2001 (Text).
2. Advanced Engineering Mathematics - 10th Ed., Erwin Keryszig, Wiley, 2011 (Text).
3. Mathematical Methods for Physics and Engineering - 3rd Ed., K. F. Riley, M. P. Hobson and S. J. Bence, Cambridge University Press, 2006 (Text).
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5. Differential Equations, Richard Bronson, Tata McGraw Hill, New Delhi, 1994 (Text).
6. Differential Equations and Linear Algebra, Stephen W. Goode and Scott A. Annin, Pearson, 2005 (Text)
7. Advanced Mathematics for Engineers Scientists, Murray R Spiegel, McGraw-Hill Education, 2009 (Text).
8. Matrices and Tensors for Physicists, A W Joshi, New Age International (1995)
9. Numerical Methods - Balagurusamy, Tata McGraw Hill, 2001 (Text).
10. Introductory Methods of Numerical Analysis, 5th Ed., S. S. Sastry, Prentice Hall of India, 2012 (Text).
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12. Introduction to Mathematical Physics, Harper Lee and Charlie Mackesy, Prentice Hall India, 1978 (Text).
13. Mathematical Methods in the Physical Sciences, 3rd. Ed., M. L. Boas, John Wiley, 2005 (Text).

**24-812-0301 Mechanics**

**(Level 200)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Explain the laws of mechanics, frames of reference, Galilean transformations and forces. | Understand | 5 | 4 |
| CO2 | Apply the concepts of laws of mechanics, frames of reference, transformations and forces in order to solve problems involving these ideas. | Apply | 6 | 4 |
| CO3 | Explain concepts of Lorentz transformations, relativity, non-absolute nature of space and time and its consequences. | Understand | 6 | 2 |
| CO4 | Apply the concepts of relativistic mechanics to reformulate the classical ideas of mass, energy, momentum and their transformation. | Apply | 6 | 4 |
| CO5 | Understand the principles of Lagrangian mechanics and solve problems involving generalized coordinates and constraints in mechanical systems. | Understand | 5 | 4 |
| CO6 | Apply Hamilton's principle and Lagrange's equations of motion of particles and systems in various mechanical scenarios. | Apply | 6 | 4 |
| CO7 | Understand the concepts of Hamiltonian mechanics and canonical transformations. | Understand | 5 | 4 |
| CO8 | Apply the Hamilton-Jacobi equation to solve problems in classical mechanics. | Apply | 6 | 4 |
| | Total Number of Hours | | 45 | 30 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | |
| CO2 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | |
| CO3 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | |
| CO4 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | |
| CO5 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | |
| CO6 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | |
| CO7 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | |
| CO8 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | |

3-High; 2-Medium; 1-Low

Module I

Frames of reference, Laws of Mechanics, Inertial frames of reference, Galilean transformation, Galilean invariance, Principle of relativity, Conservation of momentum, Non-inertial frames and fictitious forces, Centripetal force, Centrifugal force, Rotating frame of reference, Foucault's pendulum.

Module II

Michelson-Morley experiment, Ether hypothesis, Special theory of relativity, Lorentz transformations, Length contraction, Time dilation, Simultaneity, Addition of velocities, Relativistic Doppler's effect, Conservation of momentum and variation of mass, Relativistic energy, Relation between momentum and energy and conservation laws, Transformation of momentum and energy, Particles with zero rest mass.

Module III

Constraints: types of constraints, difficulties associated with constraints, generalized coordinates Kinetic energy of a system in terms of generalized velocities. Calculus of Variation: Hamilton's Principle, techniques of the calculus of variations, Lagrange's equation from Hamilton's principle. Generalized momenta, cyclic coordinates.

Applications of Lagrangian formulation: motion of a particle in space, Atwood's machine, bead sliding on rotating wire, simple pendulum, harmonic oscillator.

Module IV

Hamiltonian mechanics: Hamiltonian of a system, Hamilton's equations of motions, Canonical transformations, Generating functions.

Poisson Brackets: fundamental properties of PB, Equations of motion in Poisson Bracket form, PB and integrals of motion, Canonical invariance of PB, Lagrange brackets. Hamilton-Jacobi equation for Hamilton's principal function.

**References**


1. Mechanics, J C Upadhyaya, Ram Prasad and Sons, Agra 2017 (Text).
2. Mechanics D S Mathur, S Chand & Company, New Delhi 2007.
3. Classical Mechanics, H Goldstein, C Poole and J Safko, 3rd edition, Addison Wesley 2005 (Text).
4. Classical Mechanics – G Aruldhas, PHI learning, 2014.
5. Mechanics: Berkeley Physics Course, Vol. 1, Tata McGraw Hill Education, Noida, 2nd edition 2017.
6. The Feynman Lectures on Physics, Vol. I, Narosa Publishing House, New Delhi 2008.
7. Classical Mechanics- Rana and Joag, Tata McGrawHill 1992.
8. Classical Mechanics - V B Bhatia, Narosa Publishing House, New Delhi 1997.
9. Mechanics L. D Landau and E. N Lifshitz., Butterworth Heinemann,3rd edition 2002.

**24-812-0302 Nano-Bio Photonics**
**(Level 200)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand the basic theory and science of interaction of light with cells and tissues | Understand | 8 | 0 |
| CO2 | Understand different light delivery systems | Understand | 7 | 0 |
| CO3 | Understand fundamentals of optical imaging | Understand | 7 | 0 |
| CO4 | Understand different optical imaging techniques | Understand | 8 | 0 |
| CO5 | Understand different optical biosensors | Understand | 10 | 0 |
| CO6 | Understand photodynamic therapy | Understand | 5 | 0 |
| CO7 | Understand optical tweezers and analyze its applications | Understand | 7 | 0 |
| CO8 | Understand different tissue engineering techniques using light | Understand | 8 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | | | | | | |
| CO2 | 3 | 3 | | | | | | |
| CO3 | 3 | 3 | | | | | | |
| CO4 | 3 | 3 | | | | | | |
| CO5 | 3 | 3 | | | | | | |
| CO6 | 3 | 3 | | | | | | |
| CO7 | 3 | 3 | | | | | | |
| CO8 | 3 | 3 | | | | | | |

3-High; 2-Medium; 1-Low

MODULE I

Photobiology; interaction of light with cells with cells and tissues, Photo-process in Bio polymers human eye and vision, Photosynthesis; Photo-excitation - free space propagation, optical fibre delivery system, articulated arm delivery, hollow tube wave-guides.

Optical coherence Tomography, Fluorescence microscopy, resonance energy transfer imaging

MODULE II

Bio-imaging: Transmission microscopy, Kohler illumination, microscopy based on phase contrast, darkfield and differential interference contrast microscopy, Fluorescence, confocal and multiphoton microscopy.

Applications of bio-imaging; Bio-imaging probes and fluoropores, imaging of microbes, cellular imaging and tissue imaging

MODULE III

Optical Biosensors: Fluorescence and energy transfer sensing, molecular beacons and optical geometries of bio-sensing, Biosensors based on fibre optics, evanescent waves and interferometric Flow Cytometry: basis, flurochromes for flow cytometry, DNA analysis. Laser activated therapy; Photodynamic therapy, photo-sensitizers for photodynamic therapy, two photon photodynamic therapy.

MODULE IV

Laser tweezers and laser scissors: design of Laser tweezers and laser scissors, optical trapping using non Gaussian optical beam, manipulation of single DNA molecules, molecular motors, semi conductor Quantum dots for bio imaging. Tissue engineering using light; contouring and restructuring of tissues using laser, laser tissue regeneration

**References**


1. Introduction to bio-photonics- P.N. Prasad Wiley Interscience (2003).
2. Biomedical Photonics -A handbook - editor Tuan. Vo Dinh (CRC Press) (2002).

**24-812-0303 Basic Mechanics**
**(Level 200)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Explain the laws of mechanics, frames of reference, Galilean transformations and forces. | Understand | 5 | 0 |
| CO2 | Apply the concepts of laws of mechanics, frames of reference, transformations and forces in order to solve problems involving these ideas. | Apply | 6 | 0 |
| CO3 | Explain concepts of Lorentz transformations, relativity, non-absolute nature of space and time and its consequences. | Understand | 6 | 0 |
| CO4 | Apply the concepts of relativistic mechanics to reformulate the classical ideas of mass, energy, momentum and their transformation. | Apply | 6 | 0 |
| CO5 | Understand the principles of Lagrangian mechanics and solve problems involving generalized coordinates and constraints in mechanical systems. | Understand | 5 | 0 |
| CO6 | Apply Hamilton's principle and Lagrange's equations of motion of particles and systems in various mechanical scenarios. | Apply | 6 | 0 |
| CO7 | Understand the concepts of Hamiltonian mechanics and canonical transformations. | Understand | 5 | 0 |
| CO8 | Apply the Hamilton-Jacobi equation to solve problems in classical mechanics. | Apply | 6 | 0 |
| | Total Number of Hours | | 45 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | |
| CO2 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | |
| CO3 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | |
| CO4 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | |
| CO5 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | |
| CO6 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | |
| CO7 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | |
| CO8 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | |

3-High; 2-Medium; 1-Low

Module I

Frames of reference, Laws of Mechanics, Inertial frames of reference, Galilean transformation, Galilean invariance, Principle of relativity, Conservation of momentum, Non-inertial frames and fictitious forces, Centripetal force, Centrifugal force, Rotating frame of reference, Foucault's pendulum.

Module II

Michelson-Morley experiment, Ether hypothesis, Special theory of relativity, Lorentz transformations, Length contraction, Time dilation, Simultaneity, Addition of velocities, Relativistic Doppler's effect, Conservation of momentum and variation of mass, Relativistic energy, Relation between momentum and energy and conservation laws, Transformation of momentum and energy, Particles with zero rest mass.

Module III

Constraints: types of constraints, difficulties associated with constraints, generalized coordinates Kinetic energy of a system in terms of generalized velocities. Calculus of Variation: Hamilton's Principle, techniques of the calculus of variations, Lagrange's equation from Hamilton's principle. Generalized momenta, cyclic coordinates.

Applications of Lagrangian formulation: motion of a particle in space, Atwood's machine, bead sliding on rotating wire, simple pendulum, harmonic oscillator.

Module IV

Hamiltonian mechanics: Hamiltonian of a system, Hamilton's equations of motions, Canonical transformations, Generating functions.

Poisson Brackets: fundamental properties of PB, Equations of motion in Poisson Bracket form, PB and integrals of motion, Canonical invariance of PB, Lagrange brackets. Hamilton-Jacobi equation for Hamilton's principal function.

**References**


1. Mechanics, J C Upadhyaya, Ram Prasad and Sons, Agra 2017 (Text).
2. Mechanics D S Mathur, S Chand & Company, New Delhi 2007.
3. Classical Mechanics, H Goldstein, C Poole and J Safko, 3rd edition, Addison Wesley 2005 (Text).
4. Classical Mechanics – G Aruldhas, PHI learning, 2014.
5. Mechanics: Berkeley Physics Course, Vol. 1, Tata McGraw Hill Education, Noida, 2nd edition 2017.
6. The Feynman Lectures on Physics, Vol. I, Narosa Publishing House, New Delhi 2008.
7. Classical Mechanics- Rana and Joag, Tata McGrawHill 1992.
8. Classical Mechanics - V B Bhatia, Narosa Publishing House, New Delhi 1997.
9. Mechanics L. D Landau and E. N Lifshitz., Butterworth Heinemann,3rd edition 2002.

## 24-812-0401 Thermal and Statistical Physics
## (Level 200)

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Describe thermodynamic systems and processes, employ laws of thermodynamics in relevant thermodynamic processes and predict the efficiency of heat engines based on Carnot's cycle. | Understand | 8 | 0 |
| CO2 | Discuss entropy, thermodynamic functions, and TdS relations. | Understand | 7 | 0 |
| CO3 | Apply Maxwell's thermodynamical relations ,Gibbs Helmholtz equations and classify phase transitions and critical phenomena. | Apply | 9 | 0 |
| CO4 | Relate thermal and electrical conductivity to Transport processes. | Analyze | 6 | 0 |
| CO5 | Discuss the concept of phase space as well as microstates and macrostates and explain the statistical origin of thermodynamics and its connection to entropy. | Understand | 6 | 0 |
| CO6 | Describe the concept of microcanonical, canonical, and grand canonical ensembles, compute various thermodynamic properties of ideal gas. | Apply | 9 | 0 |
| CO7 | Discuss Maxwell Boltzmann statistics and velocity distribution, and the theory of Brownian motion. | Understand | 6 | 0 |
| CO8 | Differentiate Fermi-Dirac and Bose-Einstein distribution and discuss the thermodynamics of blackbody radiation and Bose-Einstein condensation. | Understand | 9 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | | | | | | |
| CO2 | 3 | 3 | | | | | | |
| CO3 | 3 | 3 | | | | | | |
| CO4 | 3 | 3 | | | | | | |
| CO5 | 3 | 3 | | | | | | |
| CO6 | 3 | 3 | | | | | | |
| CO7 | 3 | 3 | | | | | | |
| CO8 | 3 | 3 | | | | | | |

3-High; 2-Medium; 1-Low

Module I

Thermodynamic systems, thermodynamic equilibrium, thermodynamic variables, equation of states, laws of thermodynamics, thermodynamic process and cycles, application of first law to heat capacities, reversible and irreversible processes, conditions for reversibility, heat engine, Carnot's cycle and Carnot's engine, Carnot's theorem, Clausius theorem and inequality.

Entropy - change in entropy in reversible and irreversible processes, entropy and disorder, entropy of ideal gas. temperature- entropy diagram, entropy and second law of thermodynamics, Nernst Heat Theorem.

Module II

Thermodynamic functions- Enthalpy, Helmhlotz function, Gibbs function, Maxwell's thermodynamic relations, TdS relations-application of Maxwell's thermodynamical relations, Clausius-Clapeyron equation, thermodynamic potential, Gibbs Helmholtz equations.

Phase transitions and critical phenomena - phase diagram, first order phase transition, Clausius-Clapeyoron equation in the context of first order phase transition, Kirchhoff's equation, second order phase transition. Ehrenfest's equations, liquid helium and superfluidity.

Transport processes – momentum transport and viscosity, energy transport and thermal conductivity, charge transport & electrical conductivity.

Module III

Macroscopic and microscopic systems- general descriptions, quantum states and phase space, density distribution in phase space, Liouville's theorem, statistical origin of thermodynamics, entropy from the statistical mechanics point, ensemble, microcanonical, canonical and grand canonical ensembles.

Module IV

Distribution laws - classical and quantum statistics, Maxwell-Boltzmann distribution, velocity distribution, equipartition of energy, relationship between entropy and probability, partition function of monoatomic gas, Brownian motion.

Quantum Statistics- Bose-Einstein and Fermi-Dirac distributions, Bosons and Fermions, thermodynamic behavior of ideal Bose gas, thermodynamics of black body radiation, specific heats of solids, B-E condensation, F-D statistics. thermodynamic behavior of an ideal Fermi gas, electron gas in metals.

**References**


1. Thermal Physics-Kittel and Kroemer, W. H. Freeman; Second edition (1980) (Text).
2. Heat and Thermodynamics -D S Mathur, Sultan Chand and Sons, Revised Fifth edition (2004) (Text).
3. Heat and Thermodynamics – Zeemansky and R. H. Dittman, Tata McGraw Hill (1997)
4. Thermal Physics: with Kinetic Theory, Thermodynamics and Statistical Mechanics- S.C. Garg, R.M. Bansal, C.K. Ghosh, TataMcGraw Hill Education Private Limited; 2nd edition (2017).
5. Heat and thermodynamics- Brijlal and Subramanium, S Chand (2008)
6. Statistical Mechanics - K Huang, John Wiley & sons, 2nd edition (2008 ) (Text)
7. Modern Thermodynamics-D. Kondepudi. Ilya Prigogene, John Wiley sons (1998)
8. Statistical Mechanics- Kamal Singh, S. Chand and Co, New Delhi, 1st edition (1988)
10. Statistical Mechanics- R. K. Pathria, Butternorth-Heinemann, (1972)
11. Modern Physics- Beiser, Tata Mc Graw Hill, (2002)
12. Statistical Physics- Berkeley Physics Course Vol 5, F Reif, Tata McGraw Hill, 2011
13. Statistical Mechanics-R. K. Pathria, 2nd edition, Elsevier (2002)

## 24-812-0402 Mathematical Physics II

## (Level 200)

Pre-requisite: 24-812-0201 Mathematical Physics I

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand complex numbers, including Euler's formula, De Moivre's theorem, and the concept of nth roots. | Understand | 6 | |
| CO2 | Apply trigonometric expansions for solving problems involving separation into real and imaginary parts of various trigonometric and inverse trigonometric functions. | Understand | 8 | |
| CO3 | Understand tensors and fundamental operations, covariant and contravariant tensors. | Understand | 8 | |
| CO4 | Understand Christoffel symbols, curvature tensor and analysis of Cartesian tensors. | Understand | 8 | |
| CO5 | Understand Fourier series and Fourier transform and Laplace transform. | Understand | 6 | |
| CO6 | Utilizing Laplace transform methods to solve initial value problems, boundary value problems, and differential equations. | Apply | 8 | |
| CO7 | Understand special functions. | Understand | 8 | |
| CO8 | Apply special functions in solving differential equations. | Apply | 8 | |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO2 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO3 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO4 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO5 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO6 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO7 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |
| CO8 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | |

3-High; 2-Medium; 1-Low

Module I

Complex numbers, Euler's formula, De Moivre's theorem, nth root of complex numbers. Trigonometric expansions: sin nx, cos nx, tan nx and hyperbolic functions. Separation into real and imaginary parts of sine, cosine, tangent, logarithmic and inverse tangent functions.

Functions of complex variables: analytic functions, power series, Taylor and Laurent series. Contour integration, Cauchy's theorem, Cauchy's integral formula.

Module II

Tensor analysis: definition, law of transformations, rank of tensor, covariant and contravariant tensors. Algebra of tensors, lowering and raising of indices, contraction of tensors, fundamental tensors, metrics. Covariant derivatives, Christoffel symbols, curvature tensor, Cartesian tensors.

Module III

Fourier series: definition, applications, properties. Fourier Transform: properties, convolution theorem, solving differential equations using FT. Laplace Transform: definition, Laplace Transform of simple functions, solving differential equations using Laplace Transform. Initial value problems, boundary value problems, solving differential equations using transform methods.

Module IV

Sturm-Liouville problem, Hermitian differential equations, beta and gamma function. Series solutions to differential equations. Partial differential Equations, separation of variable method, Laplace Equation in spherical polar coordinates and spherical harmonics. Orthogonal functions, Legendre, Bessel, and Hermite and Laguerre differential equations and their solutions.

**References**


1. Tensor Calculus, David C. Kay, McGraw Hill; Revised Edition, 2011 (Text)
2. Mathematical Methods for Physicists G. B. Arfken and H. J. Weber, Academic Press, 2001 (Text).
3. Advanced Engineering Mathematics - 10th Ed., Erwin Keryszig, Wiley, 2011 (Text).
4. Mathematical Methods for Physics and Engineering - 3rd Ed., K. F. Riley, M. P. Hobson and S. J. Bence, Cambridge University Press, 2006 (Text).
5. Vector Analysis with an Introduction to Tensor Analysis - Murray R Spiegel, Tata McGraw Hill (1975) Schaum Series (Text).
6. Differential Equations and Linear Algebra, Stephen W. Goode and Scott A. Annin, Pearson, 2005 (Text)
7. Advanced Mathematics for Engineers Scientists, Murray R Spiegel, McGraw-Hill Education, 2009 (Text).
8. Matrices and Tensors for Physicists, A W Joshi, New Age International (1995)
9. Differential Equations - 3rd Ed., Shepley L. Ross, Wiley. 2007 (Text).
10. Introduction to Mathematical Physics, Harper Lee and Charlie Mackesy, Prentice Hall India, 1978 (Text).
11. Mathematical Methods in the Physical Sciences, 3rd. Ed., M. L. Boas, John Wiley, 2005 (Text).

**24-812-0403 Electronics**

**(Level 200)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand the various configurations of transistors and familiarize with the working. | Understand | 6 | 4 |
| CO2 | Understand the working of transistors as amplifiers and analyze the working and types of oscillators. | Analyze | 6 | 4 |
| CO3 | Understand the working and frequency response of operational amplifiers. | Understand | 6 | 4 |
| CO4 | Familiarize with the various operational amplifier circuits and its applications. | Apply | 5 | 4 |
| CO5 | Apply Boolean algebra in logic circuit design. | Apply | 6 | 4 |
| CO6 | Explain the working of combinational logic circuits and flip flops. | Analyze | 5 | 4 |
| CO7 | Identify the different types of modulation techniques – Amplitude, Frequency and Phase Modulation. | Analyze | 6 | 4 |
| CO8 | Define information theory, entropy, mutual information and describe the various error detection and correction techniques. | Analyze | 5 | 2 |
| | Total Number of Hours | | 45 | 30 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | | 1 | | | | |
| CO2 | 3 | 3 | | 1 | | | | |
| CO3 | 3 | 3 | | 1 | | | | |
| CO4 | 3 | 3 | | 1 | | | | |
| CO5 | 3 | 2 | | 1 | | | | |
| CO6 | 3 | 3 | | 1 | | | | |
| CO7 | 3 | 2 | | 1 | | | | |
| CO8 | 3 | 2 | | 1 | | | | |

3-High; 2-Medium; 1-Low

Module I

Bipolar Junction Transistors, PNP and NPN structures, Principle of operation, Relation between current gains in CE, CB and CC, Input and output characteristics of common emitter configuration, load line, Transistor as a switch, transistor as an amplifier, single stage and multistage amplifiers, circuit diagram and working of Common Emitter (RC coupled) amplifier with its frequency response, Concept of transistor biasing, Oscillator: crystal, optoelectronic, RC phase shift, Hartley, Colpitts, Wien Bridge.

Module II

Ideal Amplifier, Operational Amplifiers, frequency response of Op-Amps, fundamental circuits, voltage follower, inverting and non-inverting op-amps, summing and differential amplifiers, op-amp

integrator, differentiator and its applications, op-amp peak detector, Applications of op-amps: filters, comparators, sample and hold circuit, waveform generators.

Module III

Digital fundamentals: Boolean algebra, Boolean theorems, Synthesis of Boolean functions, Karnaugh diagram, logic gates, fundamental logic operations, Universal gate (NAND & NOR) combinational logic circuits, half adder, full adder, half subtractor, full subtractor, multiplexer, demultiplexer, encoder, decoder, flip-flops, RS latches, level clocking, D latcher, D flip flops, JK flip flop, JK Master slave flip-flops. Registers and counters, shift register, controlled shift registers, ripple counters, decoding gates, synchronous counters, ring counters, changing the counter modulus, decade counters.

Module IV

Digital Communication: Amplitude Modulation, double and single sideband techniques, Frequency Modulation and demodulation techniques, bandwidth requirements, pulse communication, pulse width, pulse position, pulse code modulation, information theory, entropy, mutual information, error detection and correction techniques.

**References**


1. Basic Electronics, Mitchel Schultz and Grob, 12th edition, McGraw-hill Education, 2015.
2. Basic Electronics and Linear Circuits, N.N. Bhargava, Tata McGraw-hill Publishing Company Limited, 2008.
3. Principles of Electronics, V. K. Mehta & Rohit Mehta, 11th edition, S. Chand Publication, 2014.
4. Digital circuits and design, S. Salivahanan and S. Arivazhavan, Vikas Pub. 4th Edn, 2012.
5. Fundamentals of digital circuits, A. Anadan, PHI, 2006.
6. Communication Systems, A B Carlson, 5th edition, McGraw Hill, 2011.
7. Principles of Communication Systems, Herbert Taub, Donald Schilling & Gautam Saha, 4th edition, McGraw Hill, 2017.
8. Digital Communication, Nishanth Nazimudeen, 1st edition, Cengage, 2018.

## 24-812-0404 Quantum Mechanics I

## (Level 200)

Pre-requisites: 24-812-0201 Mathematical Physics I & 24-812-0301 Mechanics

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand the shortcomings of classical mechanics and the emergence of quantum theory | Understand | 6 | 0 |
| CO2 | Illustrate the concept and significance of wave packets | Understand | 9 | 0 |
| CO3 | Explain the properties and interpretations of wave functions | Understand | 7 | 0 |
| CO4 | Apply time-independent and time-dependent Schrödinger equations | Apply | 8 | 0 |
| CO5 | Discuss the fundamental postulates of quantum mechanics | Understand | 8 | 0 |
| CO6 | Apply linear operators and eigenfunctions in quantum mechanics | Apply | 7 | 0 |
| CO7 | Solve quantum mechanical problems, including particle in a box and potential barriers | Apply | 10 | 0 |
| CO8 | Apply the Schrödinger equation to systems with spherically symmetric potentials | Apply | 5 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 1 | 2 | | | | |
| CO2 | 3 | 1 | 1 | 2 | | | | |
| CO3 | 3 | 1 | 1 | 2 | | | | |
| CO4 | 3 | 3 | 1 | 1 | 2 | 3 | | |
| CO5 | 3 | 1 | 1 | 1 | 1 | 1 | | |
| CO6 | 3 | 1 | 1 | 1 | 2 | 2 | | |
| CO7 | 3 | 3 | 1 | 1 | 2 | 2 | | |
| CO8 | 3 | 3 | 1 | 1 | 2 | 1 | | |

3-High; 2-Medium; 1-Low

Module I

Origin of quantum theory: Blackbody radiation, ultraviolet catastrophe, Planck's formulation of black body radiation, photoelectric effect, Einstein's quantum theory of photoelectric effect, Compton effect.

Wavelike properties of particles: matter waves, de Broglie hypothesis, Davisson and Germer experiment, the wave-particle duality.

Wave packets: localized wave packets, the uncertainty principle, consequences of the uncertainty principle, uncertainty relations, the motion of wave packets, propagation of wave packets without distortion, group and phase velocities.

Module II

Schrödinger wave function, Born's interpretation of wave functions, Schrödinger's equation for a particle subjected to forces, wave function and its interpretations, probability, probability current density and continuity equation, expectation values, Ehrenfest's theorem, admissibility conditions of wave functions, normalizations of wave functions, box normalization, time-dependent and time-independent Schrödinger equations, stationary states and superposition principle.

Module III

Postulates of Wave Mechanics, dynamical variables as operators, linear operators, commutator brackets, eigen functions and eigenvalues, Hermitian operators and their properties, orthogonality conditions, Schimidt's orthogonalization procedure, physical significance of eigenfunctions and eigenvalues, degeneracy, simultaneous measurability of observables, general uncertainty relations.
Representation in continuous bases: position and momentum representations in quantum mechanics, connecting position and momentum representations, matrix and wave mechanics.

Module IV

Applications of Schrödinger equation: particle in a box, square well potential with rigid walls, square well potential with finite walls, square potential barrier and quantum tunnelling, alpha decay, linear harmonic oscillator, particle in a spherically symmetric potential, separation of R, Θ and Φ equations, Hamiltonian of two interacting particles, rigid rotator, hydrogen atom, energy eigenvalues, hydrogen wave function, radial probability density functions and hydrogen atom orbitals.

**References**


1. Quantum Physics-Eisberg and Resnik, John Wiley Sons(2002) (Text)
2. Concepts of Modern Physics-Beiser, Tata McGraw Hill (2002) (Text)
3. Quantum Mechanics- G Aruldhas, Prentice Hall India (2004) (Text)
4. Quantum Mechanics: Concepts and Applications, Nouredine Zettili, John Wiley & Sons, (2001)
5. Principles of Quantum Mechanics -R. Shankar, Springer, (2014)
6. Quantum mechanics- Mathews and Venketesan, Tata McGraw Hill (2006)
7. Quantum Mechanics-Thankappan V K, New Age International, 2nd edition (2003)
8. Introduction to Quantum Mechanics – David J Griffiths, Pearson, 3rd Edn, (2018)
9. Mastering Quantum Mechanics- Essentials, Theory and Applications, Barton Zwiebach, The MIT Press, Cambridge, Massachusetts (2022)

## 24-812-0501 Quantum Mechanics II

## (Level 300)

Pre-requisites: 24-812-0402 Mathematical Physics II & 24-812-0404 Quantum Mechanics I

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Differentiate between the Schrödinger picture, Heisenberg picture, and interaction picture in quantum mechanics | Understand | 5 | 0 |
| CO2 | Apply the operator method for solving the harmonic oscillator problem | Apply | 10 | 0 |
| CO3 | Predict eigenfunctions and eigenvalues of angular momentum operators | Apply | 8 | 0 |
| CO4 | Understand Pauli Spin matrices and spin angular momentum | Understand | 7 | 0 |
| CO5 | Apply time-independent and time-dependent approximation methods in quantum mechanics | Apply | 10 | 0 |
| CO6 | Inspect transition rates in absorption/emission processes | Analyze | 5 | 0 |
| CO7 | Understand Scattering theory and scattering cross sections | Understand | 6 | 0 |
| CO8 | Apply scattering theory to study scattering from various potentials | Apply | 9 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | 1 | | | |
| CO2 | 3 | 2 | 1 | 1 | 3 | | | |
| CO3 | 3 | 3 | 1 | 2 | 2 | | | |
| CO4 | 3 | 3 | 1 | 2 | 2 | 1 | | |
| CO5 | 3 | 2 | 1 | 2 | 3 | 1 | | |
| CO6 | 3 | 3 | 1 | 3 | 3 | 1 | | |
| CO7 | 3 | 3 | 1 | 3 | 2 | 2 | | |
| CO8 | 3 | 3 | 1 | 3 | 2 | 2 | | |

3-High; 2-Medium; 1-Low

Module I

Parity operator, Solution of linear harmonic oscillator: Operator method, coherent states, matrix representation of creation, annihilation, number, position, and momentum operators of the harmonic oscillator. Pictures of quantum mechanics, Schrödinger picture, Heisenberg picture and interaction picture.

Module II

Orbital angular momentum, General formalism of angular momentum, eigenfunctions and eigenvalues of Jz and J2, matrix representation of angular momentum, geometrical representation of angular momentum, eigenfunctions and eigenvalues of Lz and L2. Spin angular momentum: general theory of spin, Pauli spin matrices.

Module III

Time independent perturbation-first order and second order correction, the stark effect, Degenerate perturbation theory; Variational method, hydrogen atom; WKB approximation, tunnelling through a potential barrier.

Time dependent perturbation theory: first order approximation, transition probability for constant and harmonic perturbations, Fermi's Golden rule.

Module IV

Scattering theory: scattering amplitude and differential cross section of spinless particles, partial wave analysis, Optical theorem, partial wave analysis for inelastic scattering, Born approximation, scattering by hard sphere.

**References**


1. Quantum Mechanics: Concepts and Applications, 2nd Edition, Nouredine Zettili, John Wiley & Sons, 2009 (Text)
2. Principles of Quantum Mechanics -R. Shankar, Springer, (2014) (Text)
3. Quantum Mechanics G Aruldhas, Prentice Hall India, ( 2004)
4. Quantum mechanics Mathews and Venketesan, Tata McGraw Hill (2006)
5. Modern Quantum Mechanics- J J Sakurai, Pearson Education, Revised Ed (2003)
6. Quantum Mechanics-Thankappan VK, New Age International (P)Ltd, 2nd edition (2003)
7. Mastering Quantum Mechanics- Essentials, Theory and Applications, Barton Zwiebach, The MIT Press, Cambridge, Massachusetts (2022)

**24-812-0502 Electrodynamics**
**(Level 300)**

Pre-requisite: 24-812-0402 Mathematical Physics II

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Explain the concepts of electrostatics, electric field, electric potential and energy density | Understand | 7 | 0 |
| CO2 | Apply the concepts of electrostatics to solve the problems relating to electric Field and electric potential | Apply | 8 | 0 |
| CO3 | Apply the concepts of magnetostatics to solve the problems relating to magnetic field and Magnetic potential | Apply | 8 | 0 |
| CO4 | Solve problems related to electromagnetic boundary conditions | Apply | 7 | 0 |
| CO5 | Understand the concepts related to Faraday's law and Maxwell's equations | Understand | 8 | 0 |
| CO6 | Analyse the propagation, reflection and transmission of plane waves | Analyse | 10 | 0 |
| CO7 | Explain magnetism as a relativistic phenomenon of electricity | Understand | 7 | 0 |
| CO8 | Explain the significance of gauge transformations in physics, particularly in the Lorentz and Coulomb gauges | Understand | 5 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 |
|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 1 | 1 | | | |
| CO2 | 3 | 1 | 1 | 1 | | | |
| CO3 | 3 | 1 | 1 | 1 | | | |
| CO4 | 3 | 3 | 1 | 1 | | | |
| CO5 | 3 | 1 | 1 | 1 | | | |
| CO6 | 3 | 1 | 1 | 1 | | | |
| CO7 | 3 | 3 | 1 | 1 | | | |
| CO8 | 3 | 3 | 1 | 1 | | | |

3-High; 2-Medium; 1-Low

Module I

Electrostatics: Electric field, Gauss's Law in integral and differential forms, applications of Guass's law, Scalar potential, Energy of continuous charge distribution, Poisson and Laplace equations, Boundary conditions and uniqueness theorem, Dielectrics, induced dipoles, polarization and field of a polarized object, Guass's law for dielectric media, Displacement field, linear dielectric and dielectric constant, energy and forces in dielectric systems.

Module II

Magnetostatics: Magnetic fields & magnetic forces, Biot-Savart law, Ampere's law, Applications of Amperes law, Magnetic vector potential, Magnetization, Torque and forces on magnetic dipoles, The field of a magnetized object, Ampere's law in magnetized material, Boundary conditions, Magnetic susceptibility and permeability.

Module III

Faraday's law of electromagnetic induction, energy and magnetic field, Maxwell's equation in vacuum and dielectric media, Solutions of Maxwell's equation in vacuum and dielectric media, Poynting's theorem, conservation of energy and momentum, Reflection and refraction of EMW at dielectric boundaries, Snell's law, total internal reflection, Brewster's angle. Electromagnetic waves in conductors, reflection at a conducting surface, frequency dependence of permittivity.

Module IV

Vector and Scalar potentials, gauge transformations- Lorentz and Coulomb gauges. Relativistic Mechanics- proper time, proper velocity, Compton scattering, Magnetism as relativistic phenomenon. Transformation of fields, the field tensor, four vectors, Maxwell's equation in tensor form.

**References**


1. Introduction to Electrodynamics, David J Griffiths, Cambridge University Press 4th edition (2020) (Text)
2. Classical Electrodynamics J.D Jackson, Wiley, 3rd Edition (2007) (Text)
3. The Feynman Lectures on Physics, Richard P Feyman, Vol 1&2, Narosa Publishing house (2008)
4. Concepts of Modern Physics, Arthur Beiser and Shobhit Mahajan, Tata Mc GrawHill (2009)
5. Electricity and Magnetism K K Tewari, S Chand & Company, 3rd Edition (2007)
6. Electricity and Magnetism D.N Vasudeva, S Chand & Company (2002)
7. Classical Electrodynamics- P S Sengupta, New Age International, 2nd Edition (2015)
8. Electromagnetic Theory and wave propagation- S N Ghosh, Narosa Publishers 2nd Ed (2002)
9. Introduction to special theory of relativity, R Resnick, Wiley India edition (2010)

**24-812-0503 Spectroscopy**
**(Level 300)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Explain the formation of fine and hyper-fine structure of spectral lines and the relative intensities of spectral lines. | Understand | 8 | |
| CO2 | Utilize coupling schemes like LS coupling and jj coupling to determine spectral terms and term symbols based on electronic configuration. | Apply | 7 | |
| CO3 | Analyze the Zeeman effect, distinguish between normal and anomalous Zeeman effect, and evaluate Zeeman Shift. | Analyze | 8 | |
| CO4 | Compare the classical and quantum interpretations of the Stark effect in Hydrogen. | Analyze | 7 | |
| CO5 | Describe the formation of rotational and vibrational spectra of molecules. | understand | 8 | |
| CO6 | Apply vibrational and IR spectroscopy for identifying simple molecular structure. | Apply | 7 | |
| CO 7 | Utilize the Franck-Condon principle to interpret intensity of electronic transitions in diatomic molecules. | Apply | 8 | |
| CO 8 | Determine the molecular structure using Raman and IR spectroscopy techniques. | Apply | 7 | |
| | Total number of hours | | 60 | |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | |
| CO2 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | |
| CO3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | |
| CO4 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | |
| CO5 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | |
| CO6 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | |
| CO7 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | |
| CO8 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | |

3-High; 2-Medium; 1-Low

Module I

Vector atom model-quantum numbers

Symmetry of atomic states, equivalent and nonequivalent electrons, normal and inverted atoms. Spectra of one electron systems: Expression for spin orbit interaction, fine structure of Hydrogen Atom, ionized Helium, alkali atoms, fine structure of doublet states- Sodium D1, D2 lines, Lande interval rule, Lamb shift, Intensity of spectral lines. Hydrogen spectra- Hyperfine structure.

Two electron systems: Spectral terms and term symbols based on electronic configuration. LS coupling, jj coupling, Pauli's exclusion principle, Hund's rule of multiplicity, selection rules, intensity rules

Module II

Zeeman effect: Normal and anomalous Zeeman effect, classical interpretation of normal Zeeman Effect, explanation based on vector atom model, Lande's g factor, Evaluation of Zeeman Shift, Zeeman effect in Sodium atom, experimental arrangement. Intensity distribution of Zeeman lines: BDO rule, Keiss and Megger's rule. Paschen- Back effect: Splitting of Sodium lines, selection rules, Zeeman and Paschen –Back effect in Hydrogen.

Stark effect : Experiment, Stark effect in Hydrogen, weak field and strong field effect: First order and second order stark effect in Hydrogen.

X-ray spectrum, continuous and characteristic X-ray spectra

Module III

Rotational spectra of diatomic molecules as rigid rotor, intensity of rotational lines, The effect of isotopic substitution, energy levels and spectrum of non-rigid rotor.

The vibrating diatomic molecule - simple harmonic oscillator, the anharmonic oscillator, the diatomic vibrating rotator - $CO_2$ and $H_2O$ molecule. Interaction of rotation and vibrations, the vibrations of polyatomic molecules and their symmetry, the influence of rotation on the spectra of linear molecules

Module IV

Electronic spectra of diatomic molecules - Born-Oppenheimer approximation, vibrational coarse structure - progressions. Intensity of vibrational transitions – the Franck-Condon principle. Dissociation energy and dissociation products. Rotational fine structure of electronic-vibrational transitions - the Fortrat diagram. Predissociation.

Raman effect - classical theory, elementary quantum theory, pure rotational Raman spectra - linear molecules, vibrational Raman spectra polarization of light and Raman effect, structure determination by IR and Raman spectroscopy-simple examples, fundamentals of SERS.

**References**


1. Introduction to Atomic Spectra, H. E. White, McGraw-Hill Inc., US (1934). (Text)
2. Elements of Spectroscopy – Gupta, Kumar and Sharma, Pragathi Prakashan Meerat, 6th edition (2011) (Text).
3. Fundamentals for Molecular Spectroscopy, 4th Ed., C. N. Banwell and E. M. McCash, McGraw Hill Education (2017) (Text).
4. Molecular structure and Spectroscopy (2nd Edition), G. Aruldhas, Prentice Hall of India (2007).

**24-812-0504 Optics II: Applied Optics**
**(Level 300)**

Pre-requisite: 24-812-0101 Optics I

| CO | CO statement | CL | Class Hrs | Lab Hrs | PSO |
|---|---|---|---|---|---|
| CO1 | Explain the basic concepts of diffraction, including Fresnel's assumptions and rectilinear propagation of light | Understand | 8 | 0 | 1,4 |
| CO2 | Apply the Fresnel-Kirchhoff integral and Fourier transform in analysing Fraunhofer and Fresnel diffractions | Apply | 7 | 0 | 1,4 |
| CO3 | Compare and contrast different types of gratings, including blazed gratings | Analyse | 7 | 0 | 1,4 |
| CO4 | Analyse the resolution and dispersive power of spectrographs and monochromators based on grating properties | Analyse | 8 | 0 | 1,4 |
| CO5 | Describe the mathematical description of polarization and different states of polarization | Understand | 7 | 0 | 1,4 |
| CO6 | Analyse the properties of polarizers, wave plates, birefringent crystals, and circular polarizers | Analyse | 8 | 0 | 1,4 |
| CO7 | Identify dextro and levo rotatory substances and explain their optical activity | Understand | 7 | 0 | 1,4 |
| CO8 | Apply Jones and Muller matrix calculus to analyse polarizers, retarders, and rotators | Apply | 8 | 0 | 1,4 |
| | Total number of hours | | 60 | 0 | |

Module I

Diffraction-Fresnel's assumptions, rectilinear propagation of light and Fresnel's theory, Fresnel's zones, theory of zone plate, Fraunhofer and Fresnel diffractions, Fresnel-Kirchhoff integral, Fourier transform in Fraunhofer diffraction, diffraction by a single slit, diffraction by a rectangular and circular aperture, limit of resolution, Fourier transforming property of lens, spatial frequency filtering

Module II

Diffraction grating, resolution of a grating, types of gratings, blazed gratings, Mountings for gratings- various mounting techniques, Grating spectrographs, resolution and dispersive power of spectrographs, single beam and double beam monochromators. Spectrometers and fluorimeters

Module III

Analysis of Polarization- Mathematical description of polarization, states of polarization, polarization ellipse, special forms, Elliptical parameters,

Double refraction, ordinary and extraordinary rays, Optical Anisotropy-Index ellipsoid, Nicol prism, Nicol prism as a polarizer. Wave plates, full wave plate, Quarter wave and Half wave plates, Birefringence-Birefringent crystals, polarisers, polarization beam splitters, Compensators and Variable retarders, Circular polarizers,

Module IV

Optical activity - Dextro and levo rotatory substances, optical activity in liquids, Half-shade plate, Laurent's half-shade polarimeter, Stress birefringence – Photoelasticity

Jones and Muller matrix calculus- Matrices for polarizer, retarder, and rotator in both representations, Neutral density filter, Muller matrix for Depolarizer

Stokes polarization parameters, Stokes vectors, Stokes parameters for polarized and unpolarized light, Stokes Intensity formula, Poincare sphere, Representation of polarization states

**References**


1. Optics, Eugene Hecht and A R Ganesan, 5th Edition, Pearson Education (2017)
2. Optics- Ajoy Ghatak, McGraw Hill (2020)
3. Polarized light – Edward Collet, Marcel Decker (1992)
4. Introduction to Optoelectronics- Wilson and Hawkes, PHI, (1996)
5. Wave optics and Applications - R. S. Sirohi, Orient Longmann (2001)
6. Optical Electronics - Thyagarajan and Ghatak, Cambridge India (2017)
7. Polarization of light - S. Huard, Wiley (1997)

## 24-812-0601 Laser Physics
## (Level 300)

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Explain line broadening mechanisms. | Understand | 6 | |
| CO2 | Describe Planck's radiation law and processes of absorption and emission of radiation. | Understand | 6 | |
| CO3 | Discuss the required conditions for laser action. | Understand | 10 | |
| CO4 | Solve rate equations for two, three and four level systems. | Apply | 10 | |
| CO5 | Describe various laser cavity modes and its propagation. | Understand | 10 | |
| CO6 | Predict the stability of laser systems. | Apply | 8 | |
| CO7 | Describe various pulse shortening techniques and its use. | Understand | 6 | |
| CO8 | Analyse and apply the safety requirement of high power lasers. | Apply | 4 | |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 2 | | | 1 | |
| CO2 | 3 | 3 | 1 | 2 | | | 1 | |
| CO3 | 3 | 3 | 1 | 2 | | | 1 | |
| CO4 | 3 | 3 | 1 | 2 | | | 1 | |
| CO5 | 3 | 3 | 1 | 2 | | | 1 | |
| CO6 | 3 | 3 | 1 | 2 | | | 1 | |
| CO7 | 3 | 3 | 1 | 2 | | | 1 | |
| CO8 | 3 | 3 | 1 | 2 | | | 1 | |

3-High; 2-Medium; 1-Low

Module I

Decay of excited states, emission broadening and linewidth due to radiative decay, broadening due to collisional decay, Doppler broadening, Voigt profile, quantum mechanical description of radiating atoms, cavity radiations-Planck's law, absorption and stimulated emission, Einstein's coefficients.

Module II

Absorption and gain, population inversion, saturation intensity, development and growth of a laser beam, threshold requirements, laser gain saturation, laser output fluctuations, laser amplifiers, regenerative amplifiers, rate equations - two, three and four level systems, pumping pathways.

Module III

Laser cavity modes - longitudinal and transverse, Fabry-Perot cavity modes, Gaussian shaped transverse modes, stable curved mirror cavities - ABCD matrices, cavity stability criteria, Gaussian beams, Hermite-Gaussian mode, propagation of Gaussian beams using ABCD matrix

Module IV

Unstable resonators, Q-switching, Gain switching, Mode locking, pulse shortening using GVD, pulse compression with gratings and prisms, ultrashort pulse laser and amplifier system, ring lasers.
Laser systems: He-Ne laser, Argon ion laser, $CO_2$ laser, Free-electron laser, Ruby laser, Nd:YAG laser, Titanium sapphire laser.

**References**


1. Laser Fundamentals, W T Silfvast, Second Edition, Cambridge University Press, New Delhi 2008 (Text)
2. Lasers - Fundamentals and Applications, K Thyagarajan and Ajoy Ghatak, Second Edition, Springer, New York, 2010 (Text)
3. Laser Physics, Peter W Milonni and Joseph H Eberly, Wiley, 2010
2. Principles of Lasers, Orazio Svelto, Fifth Edition, Springer, 2010
3. Lasers, Anthony E Siegman, Mill Valley, Calif.: University Science Books, 1986

**24-812-0602 Fibre Optics**
**(Level 300)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Explain the theory of propagation of light in planar and cylindrical waveguides. | Understand | 6 | |
| CO2 | Describe the formation of modes in a planar optical waveguide. | Understand | 6 | 4 |
| CO3 | Classify optical fibers based on their refractive index profiles. | Understand | 3 | 4 |
| CO4 | Examine the loss mechanisms in optical fibers and to compute various losses. | Analyze | 6 | 4 |
| CO5 | Compare different types of pulse broadening mechanisms in optical fibers. | Understand | 6 | |
| CO6 | Practice the use of various standard optical fiber connectors and couplers. | Apply | 4 | 6 |
| CO7 | Analyze various techniques for the testing of optical fibre systems. | Analyze | 6 | 4 |
| CO8 | Analyze the functioning of optical fiber sensors. | Analyze | 8 | 8 |
| | Total Number of Hours | | 45 | 30 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 1 | 2 | | | 1 | |
| CO2 | 3 | 3 | 1 | 2 | | | 1 | |
| CO3 | 3 | 1 | 1 | 2 | | | 1 | |
| CO4 | 3 | 3 | 1 | 2 | | | 1 | |
| CO5 | 3 | 1 | 1 | 2 | | | 1 | |
| CO6 | 3 | 3 | 1 | 2 | | | 1 | |
| CO7 | 3 | 1 | 1 | 2 | | | 1 | |
| CO8 | 3 | 3 | 1 | 2 | | | 1 | |

3-High; 2-Medium; 1-Low

Module I

Optical waveguides, numerical aperture, modes in planar waveguides, Goos-Hanchen effect, evanescent field, cylindrical fibres, step index and graded index fibres, single mode and multimode fibres, cut of wavelengths, integrated optics, channel waveguides, electro optic waveguides, i/p and o/p couplers, e-o and m -o modulators, applications of integrated optics - lenses, grating, spectrum analysers.

Module II

Transmission characteristics of optical fibres, attenuation, absorption and scattering losses, wavelengths for communication, bend losses, dispersion effects in optical fibres: material, waveguide dispersions, modal birefringence and polarization maintaining fibres, nonlinear effects in optical fibres: nonlinear losses, self-phase modulation, cross phase modulation, stimulated Raman scattering, stimulated Brillouin scattering.

Module III

Optical fibre measurements: attenuation, dispersion band width, refractive index profile. OTDR, testing of optical fibre systems, eye pattern techniques.

Fabrication and characterization of silica, polymer fibres and photonic crystal fibres, erbium doped fibres, fibre components, couplers, connectors, packaging, splicers, cables, fiber joints, fiber polishing, industrial, medical and technological applications of optical fibre.

Module IV

Fibre optic sensors: advantages of fibre optic sensors, intensity modulation and interference type sensors, intrinsic and extrinsic fibre sensors, wavelength modulated sensors, fibre Bragg grating and fibre long period grating sensors, distributed fibre optic sensors, polarisation modulation type sensors, Sagnac interferometer and fibre optic gyroscope, temperature, pressure, force and chemical sensors.

**References**


1. Optical Fibre Communication, J. M. Senior, Prentice Hall India, 1994 (Text)
2. An introduction to Fiber Optics, Ghatak and Thyagarajan, Cambridge University Press, 1998 (Text).
3. Optical Fibre Communication Systems, J. Gowar, Prentice Hall India, 1995
4. Fibre optic communication, J. Palais, Prentice Hall India, 1988.
5. Fundamentals of Fibre Optic Telecommunication, B. P. Pal., Wiley Eastern, 1994.
6. Integrated Optics, R. G. Hunsperger. Springer Verlag, 1998
7. Fundamentals of Fibre Optics, B. P. Pal, Wiley Eastern, 1994
8. Understanding Fiber Optics, J. Hecht, Pearson Edu. Inc, 2006.
9. Fibre Optic Sensors - Principles and Applications, B. D. Gupta, New India Publishing, 2006.
10. Fibre Optic Communication Systems, 3rd Edition - G.P. Agrawal, John Wiley and Sons, 2002

## 24-812-0603 Computational Methods in Optics and Photonics
## (Level 300)

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand fundamental concepts in Python to solve mathematical problems. | Understand | 4 | 0 |
| CO2 | Understand the basics of Mathematica in solving algebraic and differential equations. | Understand | 8 | 0 |
| CO3 | Apply the knowledge of eigenvalue problems to analyze the band structure of photonic crystals. | Analyze | 8 | 0 |
| CO4 | Apply ABCD matrix method for modelling optical systems. | Apply | 8 | 0 |
| CO5 | Understand the fundamentals of the FDTD method. | Understand | 8 | 0 |
| CO6 | Apply FDTD method to simulate the optical response of simple optical systems. | Apply | 8 | 0 |
| CO7 | Understand Finite Element Method. | Understand | 8 | 0 |
| CO8 | Apply FEM to simulate the optical response of simple optical systems. | Apply | 8 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 1 | 1 | 1 | 3 | 2 | 3 | |
| CO2 | 1 | 1 | 1 | 1 | 3 | 2 | 3 | |
| CO3 | 1 | 1 | 1 | 1 | 3 | 2 | 3 | |
| CO4 | 1 | 1 | 1 | 1 | 3 | 2 | 3 | |
| CO5 | 1 | 1 | 1 | 1 | 3 | 2 | 3 | |
| CO6 | 1 | 1 | 1 | 1 | 3 | 2 | 3 | |
| CO7 | 1 | 1 | 1 | 1 | 3 | 2 | 3 | |
| CO8 | 1 | 1 | 1 | 1 | 3 | 2 | 3 | |

3-High; 2-Medium; 1-Low

Module I

Introduction to Mathematica: overview of Mathematica software and its capabilities. Basics of the Mathematica interface: notebook structure, cells, evaluation, and syntax. Solving algebraic equations, differential equations, and systems of equations in Mathematica. Using built-in functions such as Solve, NSolve, and DSolve.

Maxwell equations and the wave equation, introduction to time-harmonic Maxwell equations and the Helmholtz equation.

Module II

Solving eigenvalue problems in electromagnetism, propagation of light in photonic crystals and calculation of band structure. ABCD matrix and ray tracing: introduction to the ABCD matrix method for optical systems. Ray tracing using matrix methods and transfer matrix method.

Module III

Basic principles of FDTD: discretization of space and time, finite differences, and time-stepping. Spatial discretization: discretization of the electromagnetic field components (E and H fields) in space using finite differences. Temporal discretization and Yee grid, discretization of time using finite differences or central differences, staggered grid arrangement used in FDTD method. Placement of electric field components (E) at cell faces and magnetic field components (H) at cell edges.

Boundary Conditions in FDTD, implementing boundary conditions in FDTD simulations. Perfectly Matched Layer (PML) boundary conditions for absorbing boundaries.

Module IV

Finite Element Method and its relevance in optics and photonics. Basic concepts: discretization, variational formulation, and finite element modelling. Weak formulation of partial differential equations and its application in FEM. Implementing FEM for optical simulations.

**References**


1. Mathematica by Example, by Martha L. Abell and James P. Braselton, Academic Press Inc., 2007 (text)
2. Classical Electrodynamics, J. D. Jackson, 3rd Ed. Wiley (Text).
3. Principles of Nano Optics, Bert Hecht and Lukas Novotny, Cambridge University Press, 2012 (Text).
4. An introduction to Computational Physics, Tao Pang, 2nd Ed. Cambridge University Press, 2006 (Text)
5. Computational Physics, Mark Newman, Amazon Digital Services, 2012 (Text).
6. Absorption and Scattering of Light by Small Particles, Craig Bohren and Donald Huffman, John Wiley and Sons, 1998 (Text).
7. Computational Electrodynamics: The Finite-Difference Time-Domain Method, Allen Taflove and Susan C. Hagness, Artech House 1995, (Text).
8. David B Davidson - Computational electromagnetics for RF and microwave engineering - Cambridge University Press, 2011 (Text).
9. Computational Electromagnetics, Thomas Rylander, Par Ingelström, Anders Bondeson, Springer-Verlag New York, 2013 (Text).
10. The Mathematical Theory of Finite Element Method, Susanne C. Brenner and L. Ridgway Scott, Springer-Verlag New York Inc., 2007 (Text).

**24-812-0604 Optical Instrumentation**
**(Level 300)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Design optical magnifiers and achromatic doublets. | Apply | 6 | 0 |
| CO2 | Understand the working of telescopes and adaptive optical techniques. | Understand | 9 | 0 |
| CO3 | Illustrate the working of different types of spectrometers and the mounting techniques. | Understand | 8 | 0 |
| CO4 | Compare the spectrometers based on their performance. | Apply | 7 | 0 |
| CO5 | Understand different methods in optical metrology. | Understand | 9 | 0 |
| CO6 | Design velocimeters and vibrometers based on laser doppler techniques. | Apply | 6 | 0 |
| CO7 | Describe the working of basic analytical instruments. | Understand | 8 | 0 |
| CO8 | Design spectrometers for various applications. | Apply | 7 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 2 | 1 | 1 | 1 | |
| CO2 | 3 | 3 | 1 | 2 | 1 | 1 | 3 | |
| CO3 | 3 | 3 | 1 | 2 | 1 | 1 | 1 | |
| CO4 | 3 | 3 | 1 | 2 | 1 | 1 | 1 | |
| CO5 | 3 | 3 | 1 | 2 | 1 | 1 | 3 | |
| CO6 | 2 | 3 | 1 | 2 | 1 | 1 | 1 | |
| CO7 | 3 | 3 | 1 | 2 | 1 | 1 | 1 | |
| CO8 | 3 | 3 | 1 | 2 | 1 | 1 | 1 | |

3-High; 2-Medium; 1-Low

Module I

Lens systems: Principal and meridional rays, magnifiers, ophthalmic lenses, achromatic doublets and collimators, afocal systems, relay systems and periscopes, indirect ophthalmoscopes and fundus camera.

Telescopes: transmissive telescopes and resolution, reflecting telescopes, one-, two- and three-mirror telescopes, astronomical telescopes, adaptive optics, space telescopes, field-aperture telescope.

Module II

Spectrometers: prism spectrometers, deviation and dispersion, mounting arrangements, Littrow and Wadsworth mountings, grating spectrometers, resolution and resolving power, mounting arrangements, Paschen-Runge, Czerny-Turner and Fastie-Ebert mountings, the Rowland mounting, Eagle mounting, Fourier transform spectrometers based on interferometers, Michelson and Twyman-

Green interferometer-based Fourier transform spectrometers, Fabry-Perot spectrometer, Mach-Zehnder and spherical Fabry-Perot interferometers.
Spectrometer configurations: single pass and double pass spectrometers, double monochromator spectrometers.
Comparison between resolution, resolving power, throughput and signal to noise ratio of different spectrometers.

Module III
Optical Metrology: range finders, optical RADAR, curvature and focal length measurement, Moiré technique, Talbot effect, thickness measurement, interferometric methods in small distance measurements, velocity and vibration measurements, velocity measurements using stroboscopic lamps, laser speckle photography and particle image velocimetry, laser Doppler velocimetry, optical vibrometers, different types of laser doppler vibrometers.

Module IV
Analytical Instruments: UV-Vis-IR spectrophotometers, Beer-Lambert's law, microwave and IR spectrometers , spectrofluorometers, FTIR spectrometer, Raman spectrometer.

**References**


1. Geometrical and instrumental Optics, Volume 25, edited by Daniel Malacara, Academic Press, (1988 (Text).
2. Handbook of Optical Engineering, Edited by Daniel Malacara and Brian J Thompson, Marcel Dekker Inc, 2001 (Text).
3. Fundamentals of Molecular spectroscopy, C N Banwell, McGraw-Hill Book Company, 4th edition, 2017 (Text).
4. Handbook of Analytical instruments, second edition, R S Khandpur, McGraw-Hill Education Private Limited (2006) (Text).

## 24-812-0606 Optical Sensor Technology
## (Level 300)

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Describe the principles of measurement used in different sensing schemes. | Understand | 8 | |
| CO2 | Compare the sensitivity of simple optical sensors. | Understand | 6 | 6 |
| CO3 | Explain the application of important interferometric techniques in high precision measurements. | Understand | 4 | |
| CO4 | Analyze the features and applications of a variety of optical fiber sensors used for the sensitive measurements of various physical and chemical parameters. | Analyze | 8 | 8 |
| CO5 | Construct and study the response of some sensing systems and understand the basic elements required for the realization of sensors for a particular measurand. | Apply | 8 | 8 |
| CO6 | Distinguish various optical fibre sensors based on modulation. | Analyze | 6 | 4 |
| CO7 | Examine the role of optical micro-cavities for sensing applications. | Understand | 2 | 4 |
| CO8 | Explain some emerging sensors based on photonic crystal fibers and fiber loop ringdown spectroscopy. | Understand | 3 | |
| | Total Number of Hours | | 45 | 30 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 1 | 2 | | | 1 | |
| CO2 | 3 | 3 | 1 | 2 | | | 1 | |
| CO3 | 3 | 1 | 1 | 2 | | | 1 | |
| CO4 | 3 | 3 | 1 | 2 | | | 1 | |
| CO5 | 3 | 3 | 1 | 2 | | | 1 | |
| CO6 | 3 | 3 | 1 | 2 | | | 1 | |
| CO7 | 3 | 3 | 1 | 2 | | | 1 | |
| CO8 | 3 | 3 | 1 | 2 | | | 1 | |

3-High; 2-Medium; 1-Low

Module I

Introduction to sensors, Active and Passive sensors, Sensor performance parameters, light beam as a sensing tool (optical sensor) - broad classification of optical sensors, photoelectric effect, photoconductivity, photodiode, phototransistor. Simple optical sensors - single and double optic lever; Method of Triangulation; Projected fringe technique; Remote sensing using laser-lidar for atmospheric remote sensing, lidar equation.

Module II

Interferometry for precision measurements, two-beam interferometry- Michelson, Mach Zehnder, Sagnac interferometers and applications, fringe displacement and fringe counting; Homodyne interferometer, heterodyne interferometer, super heterodyne interferometry; Multiple beam interference,Fabry Perot etalon and applications, Electron speckle pattern interferometry; Photoelastic measurements; Moire technique.

Experiential Learning: Moire pattern- displacement and refractive index (liquid) measurement, radius of curvature, focal length of spherical lenses.

Module III

Light transmission in microbend optical fibres- microbend OFS- measurements with microbend sensors; Evanescent wave (EW) phenomenon – Absorption and fluorescence, Beer lambert law, absorption and complex index, evanescent wave FOS, chemical sensors using EWFOS, evanescent wave fluorescence based sensor; Surface Plasmon resonance based fiber sensor-principle and applications; Fibre Bragg grating and Long period grating sensor, Distributed fiber optic sensing and applications- OTDR and its applications, fully distributed & quasi-distributed systems; FO smart sensing-basic architecture and example

Experiential Learning:

Study the shift in absorption or fluorescence characteristics of dyes/nanoparticles with pH and concentration. Evanescent wave optical fiber sensor- U shaped, Tapered etc. fabrication and application to refractive index and chemical sensing application

Module IV

Interferometric FOS basic principles, interferometric configurations- component, and construction of interferometric FOS - Mach-Zehnder, Michelson, Sagnac & fiber gyro-open loop and closed loop biasing scheme, Fabry-Perot configurations – application of interferometric FOS examples Optical microcavities, Whispering Gallery Modes in Optical microcavities, Passive and Active WGM microcavities, Polymer optical fiber based WGM microcavities, WGM Microcavities based sensors. Photonic crystals and photonic crystal fiber sensors, fiber loop ringdown spectroscopy

Experiential Learning:

Michelson, Mach Zehnder fiber optic sensors (using 3 dB couplers) , Whispering gallery mode sensing using optical microcavities.

**References**


1. Optical Networks: A Practical Perspective 3rd Edition, R Ramaswamy and Kumar N. Sivarajan, Morgan Kaufmann Publishers, 2010, (Text).
2. WDM Optical Networks Concepts, Design and Algorithms, Sivaram Murthy and Mohan Guruswamy. Prentice Hall, 2001 (Text).
3. Understanding Optical Communications, by Harry J.R. Dutton (pdf version http://cs5517.userapi.com/u133638729/docs/3745fff272ed/Dutton_HJR_Understanding_Optical_Communications.pdf)
4. Optoelectronic Packaging (Wiley Series in Microwave and Optical Engineering), Alan R. Mickelson, Nagesh R. Basavanhally, Yung-Cheng Lee, Wiley Blackwell, 1997.
5. WDM Technologies: Active Optical Components, Volume 1, By Niloy K. Dutta, Masahiko Fujiwara, Academic Press, 2002.
6. Clean Assembly Practices to Prevent Contamination and Damage to Optics, J.Pryatel, W.H. Gourdin (pdf version available at https://e-reports-xt.llnl.gov/pdf/328839.pdf).
7. Advanced Optical Wireless Communication Systems, Shlomi Arnon, John Barry, George Karagiannidis, Robert Schober, and Murat Uysal, Cambridge University Press, 2012.
8. Optical Wireless Communications System and Channel Modelling, Z. Ghassemlooy W. Popoola S. Rajbhandari, CRC Press, 2019.

**24-812-0607 Photonic Crystals and Optical Metamaterials**
**(Level 300)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Summarize the fundamental concepts of electromagnetic waves in periodic structures, including the Bloch theorem and photonic band structure. | Understand | 6 | 3 |
| CO2 | Explain the concept of bandgap engineering in 2D and 3D Photonic crystals, understanding how it influences the optical properties. | Understand | 5 | 4 |
| CO3 | Apply the mixing rules to analyze the macroscopic effective parameters of metamaterials, considering the optical properties of metals and dielectrics. | Understand | 6 | 3 |
| CO4 | Illustrate the optical magnetism in nature, examining the role of split-ring resonators in creating magnetic metamaterials. | Apply | 6 | 4 |
| CO5 | Explain the principles of nonlinear optics with metamaterials. | Understand | 5 | 3 |
| CO6 | Utilize the concepts of transformation optics to explain the electromagnetic cloak of invisibility. | Apply | 6 | 3 |
| CO7 | Discuss the principles behind super resolution with meta-lenses, examining how these lenses achieve subwavelength resolution in optical imaging. | Understand | 6 | 5 |
| CO8 | Evaluate the theoretical foundations and limitations associated with the concept of a perfect lens with subwavelength resolution. | Apply | 5 | 5 |
| | Total number of hours | | 45 | 30 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 3 | 1 | 1 | 2 | |
| CO2 | 3 | 3 | 1 | 3 | 1 | 1 | 2 | |
| CO3 | 3 | 3 | 1 | 3 | 1 | 1 | 2 | |
| CO4 | 3 | 3 | 1 | 3 | 1 | 1 | 2 | |
| CO5 | 3 | 3 | 1 | 3 | 1 | 1 | 2 | |
| CO6 | 3 | 3 | 1 | 3 | 1 | 1 | 3 | |
| CO7 | 3 | 3 | 1 | 3 | 1 | 1 | 3 | |
| CO8 | 3 | 3 | 1 | 3 | 1 | 1 | 3 | |

3-High; 2-Medium; 1-Low

Module I

Photonic crystals: Electromagnetic waves in periodic structures-Matrix theory of dielectric layered media, Bragg Grating,1D Photonic crystals — Bloch modes, Dispersion relation and photonic band structure.

Real and reciprocal lattices; 2D and 3D Photonic crystals; Bandgap engineering; Devices based on photonic crystals; Emerging Applications of Photonic Crystals.

Module II

Metamaterials: Macroscopic Effective Parameters, Optical properties of metals and dielectrics, Metal-Dielectric Composites and Mixing Rules-electric metamaterials-Optical Properties of Stratified Metal-Dielectric Composites-Periodic Array of Metallic Wires-Semicontinuous Metal Films-Magnetic Metamaterials-Split-Ring Resonators.

Module III

Negative-Index Metamaterials-Reversed Phenomena in Negative-Index Media-Optical negative index materials-General Recipe for Construction-Nonlinear Optics with Metamaterials-Second-Harmonic Generation and the Manley–Rowe Relations in Negative-Index Materials-Optical Parametric Amplification in Negative-index Materials.

Module IV

Super Resolution with Meta-Lenses-Perfect Lens with Subwavelength Resolution.

Transformation Optics and Electromagnetic Cloak of Invisibility-Cloaking by Coordinate Transformation.

Experimental Techniques-Fabrication of Two-Dimensional Optical Metamaterials-Characterization of Spectral Properties.

**References**


1. Fundamentals of Photonics, 3rd Edition. by Bahaa E. A. Saleh, Malvin Carl Teich (2019).
2. Fundamentals and Applications of Nanophotonics. by Joseph W. Haus (2016).
3. Optical Metamaterials: Fundamentals and Applications, W. Cai and V. Shalaev Springer (2010).
4. Optical waves in layered media, Pochi Yeh, Wiley Interscience publication (1988).
5. Photonic crystals: moulding the flow of light, John Joannopoulos, Joshua N. Winn, and Robert D. Meade, Princeton University press, Second Edition (2008).

**24-812-0608 Fourier Optics and Optical Signal Processing**
**(Level 300)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand the fundamental concepts of signals. | Understand | 8 | |
| CO2 | Explain the properties of linear systems. | Understand | 7 | |
| CO3 | Illustrate the difference between Fraunhofer and Fresnel diffraction. | Understand | 7 | |
| CO4 | Apply the principle of diffraction to specific examples. | Apply | 8 | |
| CO5 | Utilize the Fourier transform property of the lens to predict image formation by a lens. | Apply | 8 | |
| CO6 | Distinguish between coherent and incoherent imaging systems and their transfer functions. | Analyze | 7 | |
| CO7 | Explain optical correlators and acousto-optic signal processing. | Understand | 8 | |
| CO8 | Illustrate advanced pulse shaping and processing techniques. | Understand | 7 | |
| | Total hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 2 | 1 | 1 | 1 | |
| CO2 | 3 | 3 | 1 | 3 | 1 | 1 | 1 | |
| CO3 | 3 | 3 | 1 | 2 | 1 | 1 | 1 | |
| CO4 | 3 | 3 | 1 | 3 | 1 | 1 | 1 | |
| CO5 | 3 | 3 | 1 | 3 | 1 | 1 | 1 | |
| CO6 | 3 | 3 | 1 | 2 | 1 | 1 | 1 | |
| CO7 | 3 | 3 | 1 | 3 | 1 | 1 | 1 | |
| CO8 | 3 | 3 | 1 | 3 | 1 | 1 | 1 | |

3-High; 2-Medium; 1-Low

Module I

Signals: Characterization of a General signal, examples of signals, Spatial signal.

Linear Systems: Linearity and the Superposition Integral, Invariant Linear Systems, Transfer Functions.

General aspects of linear systems, Fourier transformation and spatial frequency spectrum, Linear space invariant and space variant systems. Sampling theory–Shannon-Whittaker sampling theorem, space-bandwidth product.

Module II

Fraunhofer and Fresnel diffraction, the Huygens-Fresnel Principle, Fresnel approximation, Positive and Negative Phases, Fourier transform in Fraunhofer diffraction. Examples of Fraunhofer diffraction- Rectangular aperture, Circular aperture.

Fresnel transform, Fresnel diffraction- square aperture, Fresnel propagation of a laser beam. Self imaging, Lau and Talbot effects.

Module III

Wave optics analysis of coherent optical systems. Thin lens as a phase transformation, the paraxial approximation, Fourier transform properties of lenses, different cases of image formation, Image formation in monochromatic illumination, lens law

Diffraction–limited coherent imaging, Fresnel zone plate, Operator approach to optical systems. Frequency response of diffraction-limited coherent imaging – the amplitude transfer function (ATF).

Optical Transfer Function (OTF), frequency response of a diffraction-limited incoherent imaging. Aberrations and their effects on frequency response. Comparison of coherent and incoherent imaging. Resolution beyond the diffraction limit.

Module IV

Optical Information Processing, Incoherent and Coherent Image Processing Systems, Optical Correlators, Acousto-Optic Signal Processing Systems, The Vanderlugt filter.

Pulse shaping and temporal processing, Holography and Diffractive Optics, Wave-front reconstruction, Computer Generated Holography.

**References**


1. Introduction to Fourier Optics, J. W. Goodman, McGraw-Hill. Third Edition, 2004
2. Statistical Optics, J. W. Goodman, Wiley Inter-science, 2000.
3. Fundamentals of photonics, Saleh and Teich, Wiley Interscience, 2007.
4. Optical signal processing, Anthony Vanderlugt, Wiley-Interscience

**24-812-0701 Optoelectronics**
**(Level 400)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Analyze the energy band structure of semiconductors to differentiate between direct and indirect bandgap materials. | Understand | 4 | 4 |
| CO2 | Design basic circuits utilizing semiconductor principles, evaluating dynamic resistance and capacitance in pn junctions. | Apply | 5 | 4 |
| CO3 | Evaluate LED materials, structures, and efficiencies to optimize luminous flux characteristics for various applications. | Analyze | 5 | 6 |
| CO4 | Apply LED principles in optical fiber communications, designing circuits for efficient data transmission. | Apply | 6 | 0 |
| CO5 | Apply the Shockley-Ramo theorem to assess external photocurrent in various photodetectors, considering noise characteristics. | Apply | 5 | 4 |
| CO6 | Analyze the characteristics and applications of advanced photodetector technologies, such as avalanche photodiodes and pin photodiodes. | Evaluate | 5 | 6 |
| CO7 | Assess the efficiencies and structures of various sensors and solar cells, optimizing performance for specific applications. | Analyze | 5 | 6 |
| CO8 | Apply principles of optical computing, including QSD arithmetic and symmetric coding, in designing efficient computational systems. | Apply | 10 | 0 |
| | Total Number of Hours | | 45 | 30 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 |
|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | | | 3 | | |
| CO2 | 3 | 2 | | | | | |
| CO3 | 3 | 2 | | 2 | | | |
| CO4 | 3 | 2 | | 2 | | | |
| CO5 | 3 | 2 | | 1 | | | |
| CO6 | 3 | 2 | | 1 | | | 2 |
| CO7 | 3 | 2 | | 1 | | | 2 |
| CO8 | 3 | 2 | | 1 | | | |

3-High; 2-Medium; 1-Low

Module I

Review of semiconductor concepts and energy bands, Semiconductor statistics, Extrinsic semiconductors, Direct and indirect bandgap semiconductors, pn Junction principles, pn junction reverse current, pn junction dynamic resistance and capacitances, recombination lifetime, pn junction band diagram, Heterojunctions.

Module II

Light-emitting diodes: Principles, Homo junction and hetero junction LEDs, Quantum well LEDs, LED materials and structures, LED efficiencies and luminous flux, Basic LED characteristics, LEDs for optical fibre communications, Phosphors and white LEDs, LED electronics, Semiconductor lasers.

Module III

Principle of the pn Junction photodiode, Shockley-Ramo theorem and external photocurrent, Absorption coefficient and photodetector materials, Quantum efficiency and responsivity, The pin photodiode, Avalanche photodiode, Heterojunction photodiodes, Schottky junction photodetector, Phototransistors, Photoconductive detectors, Basic photodiode circuits, Noise in photodetectors.
Image sensors: CMOS and CCD.

Module IV

Photovoltaic devices: Solar cells, Basic principles, Operating current and voltage, and Fill factor, Equivalent circuit of a solar cell, Solar cell structures and efficiencies.
Optical computing: QSD arithmetic, Symmetric coding, Optoelectronic implementation, Artificial neural networks, Optical implementation of neural networks, Optical architecture for pattern association, Optical logic gates, Optical backplane buses, Binary memory cell and Optical switches.

**References**


1. Optoelectronics and Photonics: Principles and Practices (Second Edition), S O Kasap, Pearson 2023 (Text)
2. Optoelectronic Devices and Systems (Second Edition), S C Gupta, PHI Learning Pvt Ltd 2015 (Text)
3. Optoelectronics Sensors and Instrumentation, M K Ghosh, Ed-Tech New Delhi 2018.
4. Semiconductor Optoelectronic Devices (second edition), Pallab Bhattacharya, Pearson 2017.

## 24-812-0702 Condensed Matter Physics
## (Level 400)

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Describe structural elements such as crystal planes and directions using standard notations. | Understand | 8 | 0 |
| CO2 | Explain the concepts of reciprocal lattice and Brillouin zones. | Understand | 7 | 0 |
| CO3 | Apply the theory of lattice vibrations to determine thermal properties of solids. | Apply | 8 | 0 |
| CO4 | Understand the theory, properties and classification of superconductors and explain flux quantization and Josephson effects. | Understand | 7 | 0 |
| CO5 | Explain the concept of density of states and occupation to determine macroscopic properties of solids. | Understand | 5 | 0 |
| CO6 | Formulate the problem of electrons in a periodic potential, analyze electron dynamics in semiconductors and the effect of doping on the electronic properties of semiconductors. | Analyze | 10 | 0 |
| CO7 | Outline the fundamental concepts of dielectric properties of materials- electric dipole moment electric flux density, polarizability and source of polarizability. | Understand | 6 | 0 |
| CO8 | Understand magnetic properties of materials and classify magnetic materials based on magnetic susceptibility. | Understand | 9 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | | | | | | |
| CO2 | 3 | 3 | | | | | | |
| CO3 | 3 | 3 | | | | | | |
| CO4 | 3 | 3 | | | | | | |
| CO5 | 3 | 3 | | | | | | |
| CO6 | 3 | 3 | | | | | | |
| CO7 | 3 | 3 | | | | | | |
| CO8 | 3 | 3 | | | | | | |

3-High; 2-Medium; 1-Low

Module I

Crystal symmetry and crystal systems: translational vectors and lattices, unit cell, Miller indices, symmetry operations, reciprocal lattices, hexagonal close packed structure, NaCl, CsCl, diamond and ZnS structures, X-ray diffraction and Bragg's law, powder diffraction, different types of bonding in crystals, Vandervaal's, ionic, covalent , metallic and hydrogen bonds.

Module II

Lattice vibrations: phonons, phonon spectra of monatomic and diatomic linear lattices, scattering of phonons by neutrons, experimental techniques to get phonon spectra, lattice heat capacity, Einstein's Model, Debye's Model.

Superconductivity:experimental survey, type I and type II superconductors, Meissner effect, heat capacity, energy gap, isotope effect, thermodynamics of the superconducting transitions, London equation, coherence length, BCS theory of superconductivity, flux quantisation, Josephson effects, SQUID, high temperature superconductors.

Module III

Band theory of solids: density of states, Fermi level, origin of bands, Bloch theorem, Kronig- Penney model, classification of materials based on band gap, electrical conduction in metals and semiconductors, effect of doping on Fermi level in semiconductors.

Module IV

Dielectric properties of solids: polarisability, local electric field of an atom, ferroelectric crystals, Clausius Mossotti relation, Lorentz – Lorenz formula, Curie-Weiss Law, magnetic properties of solids, dia, para and ferro magnetism, Langevin's theory of diamagnetism and paramagnetism, ferromagnetic domains, hysteresis, B-H curve, adiabatic demagnetization.

**References**


1. Solid State Physics – C Kittel, 7 th edition, John Wiley (2004)(Text)
2. Introduction to Solids – Azaroff, Tata McGraw Hill (1977)
3. Text Book of Solid State Physics - S O Pillai, New age International (2002)
4. Problems in Solid State Physics - S O Pillai,New age International (2003)
5. Solid State Physics- A J Dekker, MacMillian India Ltd (2005)
6. Solid State Physics- M A Wahab,2nd edition,Narosa Publishing House Pvt. Ltd(2005)
7. Solid State Physics, N W Ashcroft, N David Mermin, Harcourt, (1976)

**24-812-0705 Nonlinear Optics**
**(Level 400)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand the concept of nonlinear susceptibilities, symmetries of nonlinear susceptibilities, index contraction and predict frequencies generated by nonlinear optical processes. | Apply | 8 | 0 |
| CO2 | Analyze the theory of second order nonlinear effects - SHG, SFG DFG, OPO, Frequency Up/Down Conversion, principles of Phase-matching and Quasi Phase Matching conditions. | Analyze | 7 | 0 |
| CO3 | Explain the concepts of Third order nonlinearity- third order susceptibility tensor, Degenerate four wave mixing. | Understand | 9 | 0 |
| CO4 | Explain the theory behind Optical Phase Conjugation and its applications in image processing and distortion correction. | Understand | 6 | 0 |
| CO5 | Explain the theory of nonlinear scattering mechanisms. | Understand | 6 | 0 |
| CO6 | Understand the theories related to Self Focusing , Self Induced Transparency, and the propagation of optical solitons. | Understand | 9 | 0 |
| CO7 | Explain the theory of nonlinear absorption processes - Saturable Absorption, Reverse Saturable Absorption, Two photon Absorption and its applications. | Understand | 6 | 0 |
| CO8 | Analyze the theory of nonlinear Fabry-Perot etalon, optical bistability and its applications. | Analyze | 9 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | | | | | | |
| CO2 | 3 | 3 | | | | | | |
| CO3 | 3 | 3 | | | | | | |
| CO4 | 3 | 3 | | | | | | |
| CO5 | 3 | 3 | | | | | | |
| CO6 | 3 | 3 | | | | | 2 | |
| CO7 | 3 | 3 | | | | | 2 | |
| CO8 | 3 | 3 | | | | | | |

3-High; 2-Medium; 1-Low

Module I

Historical Overview of Nonlinear Optics, Non-linear polarization, physical origin of non-linear optical coefficients- Classical Anharmonic Oscillator Model, Miller's Rule, susceptibility tensors, Symmetries of nonlinear susceptibilities, Index contraction, d-matrix., Parametric and Non- parametric processes. Propagation of EMW through nonlinear media, Coupled amplitude equations for second-order processes $\chi^{(2)}$, Phase Matching conditions, Quasi Phase Matching (QPM) , second harmonic generation, sum and difference frequency generation, optical parametric processes (OPA and OPO), Frequency Up/Down conversion.

Module II

Third order nonlinearity: Third order susceptibility tensor, Degenerate four wave mixing , Phase conjugate optics- properties of phase conjugate light,Generation of phase conjugate light, FWM in optical Kerr media, coupled mode formulation, Resonators with OPC mirror, Imaging through distorting medium.

Module III

Nonlinear scattering processes - Stimulated Raman Scattering (SRS)-Quantum mechanical description of Raman scattering, Raman cross section and gain, SRS described by non-linear polarization, Anti Stokes Raman Scattering, Coherent Antistokes Raman Scattering (CARS).
Self action effects- intensity dependent refractive index, Self-focusing effect, Self-induced transparency- pulse area theorem.

Module IV

Nonlinear absorption- Two photon Absorption (TPA), Multiphoton absorption, Applications of nonlinear absorption, saturable and reverse saturable absorbers, Z-scan theory of closed aperture and open aperture scan. Nonlinear Fabry- Perot etalon (NLF), NLF as a computing element, Optical Bistability, Optical logic gates.

**References**


1. Hand book of Nonlinear optics-Richard L Sutherland, (Second Edition), Marcel Dekker Inc,(2003) (Text).
2. Nonlinear optics- Robert W Boyd, Academic Press, Elsevier, Inc (Third Edition) (2008), (Text).
3. Photonics, Elemental and Devices- V V Rampal, Wheeler Publishing (1992).
4. Lasers and Nonlinear optics- B B Laud, Wiley Eastern 3rd Edition, (2004).
5. Optical Electronics in Modern Communications -A Yariv, Oxford University Press(5th Edition), (1997).
6. Nonlinear Optics- Y R Shen, John Wiley Sons (1991).
8. Nonlinear Fibre Optics- Govind P Agarwal, Academic Press, 4th Edition(2007).
9. Quantum Electronics- A Yariv, John Wiley Sons (1989).
10. Fundamentals of Photonics-B E A Saleh, M C Teich, John Wiley Sons, 2nd edition (2007).
11. Physics of nonlinear optics-Guang S He and Song H Lie, world scientific , London (1999).
12. Fundamentals of Nonlinear Optics- P.E.Powers , CRC Press(2011).

**24-812-0706 Nanophotonics**
**(Level 400)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Describe the basics of nanophotonics considering photon propagation under various interaction potentials. | understand | 6 | 0 |
| CO2 | Explain the nanoscale optical interactions and apply nanoscale enhancement in near field optics and microscopy. | Apply | 10 | 0 |
| CO3 | Explain the Quantum confinement effects in nanomaterials. | Analyze | 8 | 0 |
| CO4 | Discuss nanostructural material behaviour and nanostructering techniques. | Analyze | 8 | 0 |
| CO5 | Explain various methods of nano- structure fabrication. | understand | 7 | 0 |
| CO6 | Characterization analysis of nanostructure size using experimental techniques. | Analyze | 7 | 0 |
| CO7 | Explain nanoplasmonics and photonic band gap nanostructures. | Apply | 7 | 0 |
| CO8 | Manipulate nanostructures to enhance secondary emission. | Analyze | 7 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 2 | | | 1 | |
| CO2 | 3 | 3 | 1 | 1 | | | 1 | |
| CO3 | 3 | 3 | 1 | 2 | | | 1 | |
| CO4 | 3 | 3 | 1 | 1 | 1 | | 1 | |
| CO5 | 3 | 2 | 1 | 2 | 1 | | 1 | |
| CO6 | 3 | 3 | 1 | 2 | 1 | | 1 | |
| CO7 | 3 | 3 | 1 | 1 | | | 1 | |
| CO8 | 3 | 3 | 1 | 1 | | | 1 | |

3-High; 2-Medium; 1-Low

Module I

Introduction to Nanophotonics – Breaking through diffraction limit, evanescent waves and optical near- field generation. Nanophotonics for real-time qualitative innovation.

Foundations of Nanophotonics- Photons and electrons- similarities and differences, Free-space propagation confinement of photons and electrons, propagation through classically forbidden zone: Tunnelling.

Localization under a periodic potential: bandgap, cooperative effects for photons and electrons, Nanoscale optical interactions: nanoscale confinement of electronic interactions, nanoscale electronic energy transfer, near-field interaction and microscopy, nanoscale enhancement of optical interactions.

Module II

Quantum confinement nature: Quantum well, Quantum wires, Quantum dots and Quantum rings.

Manifestation of quantum confinement: modification of optical properties, semiconductor quantum dots, Quantum confined stark effects, Dielectric confinement effects.

Molecular nanotechnology and Quantum dot lasers.

Nano-structural material behaviour- nanoparticles, nano clusters, and nanocrystals. Nanomaterials and nano structuring techniques – Carbon nanotubes, single walled and multiwalled carbon nanotubes.

Module III

Manufacturing methods of nanomaterials: Top-down approach, Bottom-up approach, Combined Top-down and Bottom-up manufacturing.

Growth methods of Nanomaterials and nanoparticles – MBE, MOCVD, LPE, LAVD.

Characterization of Nanomaterials – X-ray Diffraction (XRD), X-ray Photoelectron Spectroscopy (XPS), TEM, SEM, RHEED, EDS, SPM, STM.

Module IV

Nanoplasmonics: optical properties of metal-nano particles, size dependent absorption and scattering of coupled nanoparticles metal-dielectric core- shell nanoparticles, local electromagnetic fields in metal nanoparticles.

Photonic Crystals: Basic concepts: band gap and band structures in two and three dimensional lattices, periodic structures in nature, experimental methods of fabrication.

Plasmonic enhancement of secondary radiation: classification of secondary radiations, enhancement of emission and scattering of light, local density of states in plasmonic nanostructures.

Hotspots in plasmonic nanostructures, Raman-scattering enhancement in metal-dielectric nanostructures, luminescence enhancement in metal-dielectric nanostructures.

**References**


1. Nanophotonics- P N Prasad, Wiely Interscience(2003) (Text)
2. Principles of Nanophotonics- Motoich Ohtsu, KiyoshKohayish CRC Press (2012)
3. Nano materials Handbook- Ahemmed Bunaina, CRC Press , 2nd Edition (2009)
4. Nanostructured materials and Nanotechnology- Haro Singh Nalwa Academic Press (concise edition) USA (2002)

**24-812-0707 Laser Spectroscopy**
**(Level 400)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Describe the importance of lasers in spectroscopy. | Understand | 6 | |
| CO2 | Compare principles of photo acoustic and optothermal spectroscopy. | Analyze | 6 | |
| CO3 | Enumerate the importance of ionization spectroscopy. | Analyze | 8 | |
| CO4 | Discuss the difference between magnetic resonance and fluorescence spectroscopy. | Analyze | 8 | |
| CO5 | Describe various multiphoton spectroscopic processes. | Understand | 8 | |
| CO6 | Discuss the importance of Laser Raman Spectroscopy. | Understand | 8 | |
| CO7 | Analyze various techniques to measure ultra short pulses. | Analyze | 8 | |
| CO8 | Assess recent laser spectroscopic techniques for a particular use. | Evaluate | 8 | |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 2 | | | 1 | |
| CO2 | 3 | 3 | 1 | 2 | | | 1 | |
| CO3 | 3 | 3 | 1 | 2 | | | 1 | |
| CO4 | 3 | 3 | 1 | 2 | | | 1 | |
| CO5 | 3 | 3 | 1 | 2 | | | 1 | |
| CO6 | 3 | 3 | 1 | 2 | | | 1 | |
| CO7 | 3 | 3 | 1 | 2 | | | 1 | |
| CO8 | 3 | 3 | 1 | 2 | | | 1 | |

3-High; 2-Medium; 1-Low

Module I

Advantages of lasers in spectroscopy, Frequency Modulation, Intra-cavity Laser Absorption Spectroscopy, Cavity Ring-Down Spectroscopy, Fluorescence Excitation Spectroscopy, Photoacoustic Spectroscopy, Optothermal Spectroscopy.

Module II

Ionization Spectroscopy – photo-ionization, collision-induced and field ionization, Sensitivity of ionization Spectroscopy, Pulsed versus CW Lasers for photo-ionization, resonant two-photon ionization combined with mass spectroscopy, optogalvanic spectroscopy, laser magnetic resonance and Stark spectroscopy, laser induced fluorescence spectroscopy

Module III

Linear and nonlinear absorption, saturation spectroscopy, Polarization spectroscopy, Multiphoton spectroscopy, two-photon absorption spectroscopy, Doppler-Free Multiphoton Spectroscopy, Experimental techniques of linear Laser Raman Spectroscopy, Nonlinear Raman Spectroscopy, Coherent Anti-Stokes Raman Spectroscopy, Resonant CARS and BOX CARS, Surface Enhanced Raman Spectroscopy

Module IV

Time resolved laser spectroscopy, Measurement of Ultrashort Pulses, Streak Camera, Optical Correlator for Measuring Ultrashort Pulses, FROG Technique, SPIDER Technique, Lifetime Measurement with Lasers, Spectroscopy in the Pico-to-Attosecond Range, Applications, Laser Induced Breakdown Spectroscopy, Laser Cooling and trapping of atoms, Fluorescence Correlation Spectroscopy, Optical Frequency Combs

**References**


1. Laser Spectroscopy Vol. 2 Experimental Techniques, Wolfgang Demtröder, Springer Berlin Heidelberg (2008) (Text)
2. Femtosecond Optical Frequency Comb: Principle, Operation and Applications, Jun Ye, Steven T Cundiff, Springer New York, 2010
3. Photoacoustics and Photoacoustic Spectroscopy, A. Rosencwaig, Wiley Interscience, New York, 1980
4. Laser cooling and trapping, H J Metcalf and P Straten, Springer New York, 1999

## 24-812-0708 Quantum Optics and Quantum Computing
## (Level 400)

Pre-requisite: 24-812-0404 Quantum Mechanics I & 24-812-0501 Quantum Mechanics II

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand quantized electromagnetic field and the origin of number states. | Understand | 7 | 0 |
| CO2 | Illustrate the concept of coherent states and squeezed states. | Apply | 8 | 0 |
| CO3 | Examine optical coherence, photon correlation, and photon statistics. | Apply | 10 | 0 |
| CO4 | Summarize the squeezed light generation and applications. | Understand | 5 | 0 |
| CO5 | Analyse the concepts of hidden variable, entanglement and interferometric measurements. | Analyze | 9 | 0 |
| CO6 | Discover the interaction between atoms and quantised fields. | Analyze | 6 | 0 |
| CO7 | Explain the concept of qubits and quantum gates. | Analyze | 7 | 0 |
| CO8 | Classify various quantum algorithms and quantum hardware. | Analyze | 8 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 2 | 1 | 1 | | |
| CO2 | 3 | 3 | 1 | 2 | 1 | 2 | | |
| CO3 | 3 | 3 | 1 | 3 | 1 | 3 | | |
| CO4 | 3 | 2 | 1 | 3 | 2 | 1 | | |
| CO5 | 3 | 3 | 1 | 2 | 2 | 1 | | |
| CO6 | 3 | 3 | 1 | 3 | 3 | 3 | | |
| CO7 | 3 | 3 | 1 | 1 | 3 | 1 | | |
| CO8 | 3 | 2 | 1 | 1 | 3 | 1 | | |

3-High; 2-Medium; 1-Low

Module I

Concept of density matrix and its properties: Quantization of EMF, Fock/Number states, Expansion in number states, Coherent States, Displacement operator, Squeezed States, Squeezing operator, Coherence properties of EMF: First order optical coherence, Photon correlation measurements, Hanbury Brown-Twiss experiments

Module II

Photon counting measurements, Classification of light by photon statistics, Photon bunching, Photon antibunching, Squeezed light: Generation and application of squeezed light, Resonant light atom interactions, Two level atom approximation, Rabi oscillations.

Module III

EPR argument, experimental studies, Bell's inequalities in quantum optics, nondemolition measurements, quantum coherence, Entanglement and interferometric measurements. Deflection of atoms by light, Kapitza- Dirac effect, Interaction between Atoms and quantized fields- dressed fields, Jaynes - Cummings model.

Module IV

Introduction to quantum bits (Qubits), Representation of qubits using Dirac notation, superposition and entanglement of qubits, basic quantum gates, no-cloning theorem and quantum teleportation, quantum algorithms, quantum computing hardware, applications of quantum computing.

**References**


1. Quantum Optics -D F Walls, G J Milburn Springer Verlag, 2nd edition (2008) (Text).
2. Quantum Optics an Introduction - Mark Fox Oxford University Press (2004) (Text).
3. Introduction to Quantum Optics From the Semi-classical Approach to Quantized Light, Alain Aspect , Claude Fabre , Gilbert Grynberg, Cambridge University Press, 2010, (Text).
4. Introductory Quantum Optics Christopher Gerry and Peter L knight, Cambridge University, 2004.
5. Quantum computing for everyone -Chris Bernhardt, MIT Press, Cambridge, 2019 (Text).
6. Quantum Computation and Quantum Information: 10th Anniversary Edition, Michael A. Nielsen & Isaac L. Chuang, MIT Press, Cambridge, 2011.
7. Optical Coherence and quantum optics, Leonard Mandel, Emil Wolf, Cambridge University Press, 2nd Edition (2013).
8. Fundamentals of Quantum Optics- John R Klauder and ECG Sudarshan, Dover publication (2006).
9. Quantum Optics- Werner Vogel, Dirk-Gunnar Welsch, Wiley VCH, 3rd edition (2006).

## 24-812-0709 Advanced Electromagnetic Theory
## (Level 400)

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand the frequency dispersion characteristics of dielectrics, conductors, and plasma. | Understand | 6 | 0 |
| CO2 | Apply the concepts of the dielectric function of metals to study their roles in defining phenomena like bulk, surface, and localized modes in small particles. | Apply | 6 | 0 |
| CO3 | Understand the inhomogeneous electromagnetic wave equation. | Understand | 4 | 0 |
| CO4 | Apply the knowledge of retarded fields to study the field of fast moving particles and the mechanism of radiation. | Apply | 10 | 0 |
| CO5 | Illustrate electromagnetic scattering and antenna theory, including multipole expansion and Dyadic Green's functions, as well as their application in analyzing electric fields. | Understand | 8 | 0 |
| CO6 | Apply Mie theory, antenna theory and Green's functions for the optical response of nanoscale structures. | Apply | 8 | 0 |
| CO7 | Understand computational methods in electromagnetics, including analytical solutions and numerical techniques like FDTD and FEM. | Understand | 8 | 0 |
| CO8 | Apply the analytical methods, FDTD and FEM to analyze electromagnetic response of simple systems. | Analyze | 10 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | 2 | 1 | 2 | |
| CO2 | 3 | 2 | 1 | 1 | 2 | 1 | 2 | |
| CO3 | 3 | 2 | 1 | 1 | 2 | 1 | 2 | |
| CO4 | 3 | 2 | 1 | 1 | 2 | 1 | 2 | |
| CO5 | 3 | 2 | 1 | 1 | 2 | 1 | 2 | |
| CO6 | 3 | 2 | 1 | 1 | 2 | 1 | 2 | |
| CO7 | 3 | 2 | 1 | 1 | 2 | 1 | 2 | |
| CO8 | 3 | 2 | 1 | 1 | 2 | 1 | 2 | |

3-High; 2-Medium; 1-Low

Module I

Frequency dispersion characteristics of dielectrics, conductors and plasma, simple model of dispersion, anomalous dispersion and resonant absorption, low frequency behaviour and conductivity, high frequency behaviour and plasma frequency. Dielectric function of metals, Drude

model, Interband transitions, bulk plasmons, surface modes, localized modes in metallic particles, excitation of the localized modes.

Module II

Inhomogeneous electromagnetic wave equation, Retarded potentials and fields of a continuous charge distribution, Lienard-Wiechert potentials and electric and magnetic fields for a moving point charge, electric dipole radiation, magnetic dipole radiation, radiation by an arbitrary source, radiation pattern and power radiated by a moving point charge, total power radiated by an accelerated charge: Larmor formula and its relativistic generalization, angular distribution of radiation emitted by an accelerated charge, radiation reaction force.

Module III

Electromagnetic scattering and antennas: multipole expansion of potential, field of a dipole in coordinate-free form and plotting it using Octave, electric field due to a uniformly polarized sphere and plotting it using Octave. Dyadic Green's functions, plotting the electric near-field and far-field of a radiating dipole using Green's functions.

Rayleigh and Mie scattering, Mie modes, Mie modes in dielectric particles and their antenna properties.

Dipole antenna, fundamental antenna parameters, half-wave dipole, antenna array and diffraction. Antenna modes in metallic particles of simple geometry, dark and bright modes.

Module IV

Computational methods in electromagnetics: simple systems having analytical solutions, field of a homogeneous sphere placed in a quasi-static electric field, Finite Difference Time-Domain method (FDTD), Finite Element Method (FEM).

**References**


1. An Introduction to Computational Physics, Tao Pang, 2nd Ed. Cambridge University Press, 2006 (Text).
2. Classical Electrodynamics, J. D. Jackson, 3rd Ed. Wiley, 1998 (Text).
3. Principles of Nano Optics, Bert Hecht and Lukas Novotny, Cambridge University Press, 2012 (Text).
4. Antenna Theory: Analysis and Design, Constantine A. Balanis, 4th Ed. Wiley, 2016 (Text).
5. Computational Electrodynamics: The Finite Difference Time-Domain Method, Allen Taflove and Susan C. Hagness, Artech House 1995 (Text).
6. Computational Electromagnetics for RF and Microwave Engineering, David B Davidson, Cambridge University Press, 2011 (Text).
7. Computational Electromagnetics, Thomas Rylander, Par Ingelström, Anders Bondeson, Springer-Verlag, New York, 2013 (Text).

## 24-812-0806 Optomechanical Engineering
## (Level 400)

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand the principles and materials required for opto-mechanical systems. | Understand | 5 | 3 |
| CO2 | Understand basic drawings of optical components and systems. | Understand | 6 | 3 |
| CO3 | Analyse the characteristics of the materials for opto-mechanical systems. | Analyse | 5 | 4 |
| CO4 | Analyse the integrated tolerance | Analyse | 6 | 4 |
| CO5 | Understand the design and mounting of small mirrors and lenses | Understand | 6 | 4 |
| CO6 | Understand the various kinematic constraints in mounting | Understand | 5 | 4 |
| CO7 | Model simple opto-mechanical mounts | Apply | 6 | 4 |
| CO8 | Understand various methods of fabricating opto-mechanical mounts | Understand | 6 | 4 |
| | Total Number of Hours | | 45 | 30 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 2 | 1 | 1 | | |
| CO2 | 3 | 3 | 1 | 2 | 1 | 2 | | |
| CO3 | 3 | 3 | 1 | 3 | 1 | 3 | 2 | |
| CO4 | 3 | 2 | 1 | 3 | 2 | 1 | 2 | |
| CO5 | 3 | 3 | 1 | 2 | 2 | 1 | 2 | |
| CO6 | 3 | 3 | 1 | 3 | 3 | 3 | 2 | |
| CO7 | 3 | 3 | 1 | 3 | 3 | 1 | | |
| CO8 | 3 | 2 | 1 | 3 | 3 | 1 | 2 | |

3-High; 2-Medium; 1-Low

Module I

Basic computerized drawing, drawings of optical components and systems, dimensional tolerances and error budgets. Principles of opto mechanical design-structural and kinematic aspects- vibration control. Materials properties and selection criteria.

Module II

Opto-Mechanical Characteristics of Materials: Materials for opto-mechanical systems - physical, mechanical, thermal properties, dimensional stability, hysteresis, Inhomogeneity and anisotropy, temporal stability, integrated tolerance analysis.

Module III

Design and Mounting of Small Mirrors and lenses, Surface contact mounting, stress variations with surface radius, preload, material, temperature, cemented and air space doublet, linear, tilt and rotary adjustment mechanisms, kinematic constraints and degrees of freedom, coupling methods, design guide lines.

Module IV

Analysis of the Opto-Mechanical Design Interface, structural analysis using Finite Element principles, modelling, analysis and optimization of simple opto-mechanical mounts, optimum design for minimum stress transfer, Fabrication methods.

**References**


1. Handbook of Optomechanical Engineering, Ahmad, Anees, CRC Press (2017).
2. Opto-Mechanical Systems Design, Volume 1_ Design and Analysis of Opto-Mechanical Assemblies, Paul Yoder, Daniel Vukobratovich, CRC Press (2015).
3. Optomechanical Systems Engineering, Keith J. Kasunic , Wiley (2015).

**24-812-0807 Laser Systems and Laser Applications**
**(Level 400)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand about different type of laser systems. | Understand | 8 | 0 |
| CO2 | Understand about classification of lasers. | Understand | 7 | 0 |
| CO3 | Understand about laser welding. | Understand | 7 | 0 |
| CO4 | Understand about material removal using lasers. | Understand | 8 | 0 |
| CO5 | Understand about lasers in chemistry. | Understand | 8 | 0 |
| CO6 | Analyze how lasers can be used to monitor ultrafast processes. | Analyze | 7 | 0 |
| CO7 | Understand about holography. | Understand | 7 | 0 |
| CO8 | Analyze applications of holography. | Analyze | 8 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | | | | 1 | |
| CO2 | 3 | 3 | 1 | | | | 1 | |
| CO3 | 3 | 3 | 1 | | | | 1 | |
| CO4 | 3 | 3 | 1 | | | | 1 | |
| CO5 | 3 | 3 | 1 | | | | 1 | |
| CO6 | 3 | 3 | 1 | | | | 1 | |
| CO7 | 3 | 3 | 1 | | | | 1 | |
| CO8 | 3 | 3 | 1 | | | | 1 | |

3-High; 2-Medium; 1-Low

Module I

Classification of lasers- two level, three level and four level laser systems.

He-Ne laser, Ar -ion laser, Kr- ion laser, He-Cd laser, Copper vapour laser, $CO_2$ laser, $N_2$ laser, Excimer laser, X-ray laser, FEL laser.

Module II

Industrial applications of lasers, Laser welding, laser surface treatments, laser-induced material removal- cutting, scribing, marking.

Module III

Lasers in chemistry- laser isotope separation, laser induced chemical reactions- IR photochemistry. Ultrafast processes in Bio-molecules-monitoring, fast chemical reactions, study of photochemical processes and stimulation photochemical reactions.

Module IV

Holography, Hologram recording and reconstruction, thin and thick holograms, applications of holography in NDT and pattern recognition.

**References**


1. Laser Fundamentals - William T Silfvast, Cambridge University Press, 2nd Edition(2008) (Text).
2. Laser Processing and Analysis of Materials- W WDuley , Plenum Press (1983)(Text).
3. Industrial applications of lasers- John F Ready, Accademic Press, USA, 2nd Edition, ISBN 0-12-583961-8 (1997)(Text).
4. Lasers, Principles , Types and Applications- K R Nambiar, New Age International Delhi (2004), (Text).
5. Laser picosecond Spectroscopy and photochemistry of Biomolecules, V S Letokhov(Ed.), Adam Hilger, Bristal and Philadelphia (1987).
6. Lasers and Non-linear optics – B B Laud, 3rd Edition, New Age International Private Limited, 2011.
7. Fundamentals of Photonics- B E Saleh , M Teich, John Wiley Sons 2nd Edition (2007).
8. Optical Holography- P Hariharan, Cambridge University Press, 2nd Edition (1996).
9. Lasers in Medicine – H K KCobener, Wiley Sons.
10. Laser Cooling and Trapping - H J Metcalf and P Van der Straten, Springer Verlag, (1999).
11. Optical computing – D G Beitelson , MIT Press, (2000).
12. Laser Processing and Chemistry- Dieter Bauerle, Springer Verlag, 3rd Edition (2000).
13. Wave Optics and its applications, R S Sirohi, Orient Longmann (2001).
14. Spectroscopy, Luminescence and radiation centre in minerals-A S Marfunin, Springer Verlag, NY (1997).
15. Luminescence in solids-DRVij, Plenum Press, New York (1998).

**24-812-0808 Biophotonics**
**(Level 400)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand the basic theory and science of interaction of light with cells and tissues. | Understand | 8 | 0 |
| CO2 | Understand different light delivery systems | Understand | 7 | 0 |
| CO3 | Understand fundamentals of optical imaging | Understand | 7 | 0 |
| CO4 | Analyze different optical imaging techniques | Analyze | 8 | 0 |
| CO5 | Understand different optical biosensors | Understand | 10 | 0 |
| CO6 | Understand photodynamic therapy | Understand | 5 | 0 |
| CO7 | Understand optical tweezers and analyze its applications | Understand | 7 | 0 |
| CO8 | Analyze different tissue engineering techniques using light | Analyze | 8 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | | | | 1 | |
| CO2 | 3 | 3 | 1 | | | | 1 | |
| CO3 | 3 | 3 | 1 | | | | 1 | |
| CO4 | 3 | 3 | 1 | | | | 1 | |
| CO5 | 3 | 3 | 1 | | | | 1 | |
| CO6 | 3 | 3 | 1 | | | | 1 | |
| CO7 | 3 | 3 | 1 | | | | 1 | |
| CO8 | 3 | 3 | 1 | | | | 1 | |

3-High; 2-Medium; 1-Low

MODULE I

Photobiology; interaction of light with cells with cells and tissues, Photo-process in Bio polymers human eye and vision, Photosynthesis; Photo-excitation - free space propagation, optical fibre delivery system, articulated arm delivery, hollow tube wave-guides.

Optical coherence Tomography, Fluorescence microscopy, resonance energy transfer imaging

MODULE II

Bio-imaging: Transmission microscopy, Kohler illumination, microscopy based on phase contrast, darkfield and differential interference contrast microscopy, Fluorescence, confocal and multiphoton microscopy.

Applications of bio-imaging; Bio-imaging probes and fluorophores, imaging of microbes, cellular imaging and tissue imaging

MODULE III

Optical Biosensors: Fluorescence and energy transfer sensing, molecular beacons and optical geometries of bio-sensing, Biosensors based on fibre optics, evanescent waves and interferometric Flow Cytometry: basis, flurochromes for flow cytometry, DN Aanalysis. Laser activated therapy; Photodynamic therapy, photo-sensitizers for photodynamic therapy, two photon photodynamic therapy.

MODULE IV

Laser tweezers and laser scissors: design of Laser tweezers and laser scissors, optical trapping using non Gaussian optical beam, manipulation of single DNA molecules, molecular motors, semiconductor Quantum dots for bio imaging. Tissue engineering using light; contouring and restructuring of tissues using laser, laser tissue regeneration

**Refences**


1. Introduction to bio-photonics- P.N. Prasad Wiley Interscience (2003)
2. Biomedical Photonics -A handbook - editor Tuan.Vo Dinh (CRC Press) (2002)

**Solar Cells**
**(Level 400)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Demonstrate the knowledge of semiconductor physics for photovoltaic application. | Understand | 6 | 6 |
| CO2 | Apply the principle of solar energy conversion and calculate the conversion efficiency. | Apply | 6 | 6 |
| CO3 | Explain the basics of thin film solar cell. | Understand | 5 | 0 |
| CO4 | Outline the principle on which dye sensitized solar cell works on and its fabrication using novel dyes. | Understand | 6 | 6 |
| CO5 | Develop understanding of organic solar cell and BHJ solar cells. | Understand | 5 | 0 |
| CO6 | Demonstrate the basics of perovskite solar cell and its principle and fabrication method | Understand | 6 | 0 |
| CO7 | Understand the new field of research in solar cell by using nanomaterials and band gap engineering of these nanomaterials. | Understand | 6 | 6 |
| CO8 | Apply the understanding of connection of solar PV modules and its design to analyze the PV module power output. | Apply | 5 | 6 |
| | Total Number of Hours | | 45 | 30 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 2 | | 1 | | |
| CO2 | 3 | 3 | 1 | 3 | | 3 | | |
| CO3 | 3 | 3 | 1 | | | | | |
| CO4 | 3 | 3 | 1 | 2 | | 3 | | |
| CO5 | 3 | 3 | 1 | | | | | |
| CO6 | 3 | 3 | 1 | | | | | |
| CO7 | 3 | 3 | 1 | | | | | |
| CO8 | 3 | 3 | 1 | 1 | | 3 | | |

3-High; 2-Medium; 1-Low

Module I

Fundamentals of solar PV cells and systems: semiconductors as basis for solar cells materials and properties, charge carrier generation and recombination, P-N junction, I-V characteristics of solar cells in dark and light, principle of solar energy conversion, conversion efficiency.

Module II

Crystalline silicon and III-V solar cells, thin film solar cells: amorphous silicon, quantum dot solar cells. Dye Sensitized solar cells, fabrication of dye sensitized solar cells, design of novel dyes, design of solid electrolytes materials, counter electrode engineering.

Module III

Introduction to organic solar cells, bulk heterojunction (BHJ) solar cells, morphology and charge separation in BHJ, design of low bandgap polymers.

Perovskite Solar Cells, fabrication of perovskite solar cells, photophysics in perovskite solar cells, stability in perovskite solar cells.

Module IV

Nanomaterials for photovoltaics, PV panels with nanostructures, band gap engineering and optical engineering

Solar PV modules: series and parallel connections, mismatch between cell and module, design and structure, PV module power output

**References**


1. Solar Photovoltaics: Fundamental, Technologies and Application, Chetan Singh Solanki, Edition 3, PHI Learning Pvt. Ltd., 2015.
2. Introduction to Photovoltaics, John Balfour, Micheal Shaw, Sharlene Jarosek, Jones & Bartlett Publishers, 2012.
3. Dye-sensitized Solar Cells (Fundamental Sciences, Chemistry), Kuppuswamy Kalyanasundaram, EPFL Press, 1st edition, 2010.
4. Organic Solar Cells: Theory, Experiment, and Device Simulation, Wolfgang Tress, Springer Cham, 2014.
5. Perovskite Solar Cells: Properties, Application and Efficiency, Muruli Banavoth, Nova science publishers, 2019.
6. Nanostructured materials for solar cell application, Katsuaki Tanabe, MDPI books, 2022.

## 24-812-0901 Industrial Photonics
## (Level 500)

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand various fiber optic components used in optical communication industry. | Understand | 8 | 6 |
| CO2 | Understand the role of active optical components in optical communication. | Understand | 6 | |
| CO3 | Understand different optical networking terminologies. | Understand | 2 | 8 |
| CO4 | Understand various physical network topologies. | Understand | 8 | |
| CO5 | Compare existing wireless access schemes. | Analyze | 8 | |
| CO6 | Analyze the nature of optical wireless channel. | Analyze | 8 | |
| CO7 | Analyze the role of various tools for fiber optic assembly. | Analyze | 2 | 8 |
| CO8 | practice the use of fusion splicer to make permanent fibre joints. | Apply | 3 | 8 |
| | Total Number of Hours | | 45 | 30 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | | | | 1 | |
| CO2 | 3 | 3 | 1 | | | | 1 | |
| CO3 | 3 | 3 | 1 | | | | 1 | |
| CO4 | 3 | 3 | 1 | | | | 1 | |
| CO5 | 3 | 3 | 1 | | | | 1 | |
| CO6 | 3 | 3 | 1 | | | | 1 | |
| CO7 | 3 | 3 | 1 | | | | 1 | |
| CO8 | 3 | 3 | 1 | | | | 1 | |

3-High; 2-Medium; 1-Low

Module I

Optical components for communication, theory and principles of operation, Directional couplers, Variable Optical Attenuator (VOA), Polariser, Polarisation controller, isolators, circulators, multiplexers, wavelength filters, fiber gratings, Arrayed Waveguide Grating (AWG), Dielectric Thin-Film Filters, Active Optical Components, Tunable light sources, Optical switches, Optical amplifiers.

Module II

Introduction to optical networks, Optical network evolution and concepts: Optical networking terminology, Optical network node and switching elements, Layers of optical network, SDH/SONET

Layering, Frame structure, Physical network topologies, Network protection, Access networks, Passive Optical Networks, Optical Interconnects, Data Centers.

Module III
Existing wireless access schemes, Potential optical wireless communication (OWC) application areas, Optical sources, detectors, Nature of optical wireless channel, Hardware aspects of receiver-amplifier in the indoor channel environment, visible light communication, LiFi technology.

Module IV
Fiber Optic Assembly: Reliability requirements, Fiber Optic Standards, Assembly environment:- clean rooms, classification- Tools for Fiber optic assembly- strippers, cleavers-Instruments for test purpose-IL Meter, BR Meter, Optical Spectrum Analyzer, Optical power meters, OTDR, Fiber optic Sources-Fiber joints-connectors, splices, Fusion splicers-Fiber polishing-Fiber cable design and structures-Photonic Packaging-Passive and active component packaging.

**References**


1. Optical Networks: A Practical Perspective 3rd Edition, R Ramaswamy and Kumar N. Sivarajan, Morgan Kaufmann Publishers, 2010, (Text).
2. WDM Optical Networks Concepts, Design and Algorithms, 2002 – Sivaram Murthy and Mohan Guruswamy. Prentice Hall, 2001 (Text).
3. Understanding Optical Communications, by Harry J.R. Dutton (pdf version http://cs5517.userapi.com/u133638729/docs/3745fff272ed/Dutton_HJR_Understanding_Optical_Communications.pdf)
4. Optoelectronic Packaging (Wiley Series in Microwave and Optical Engineering), Alan R. Mickelson, Nagesh R. Basavanhally, Yung-Cheng Lee, Wiley Blackwell, 1997.
5. WDM Technologies: Active Optical Components, Volume 1, By Niloy K. Dutta, Masahiko Fujiwara, Academic Press, 2002.
6. Clean Assembly Practices to Prevent Contamination and Damage to Optics, J. Pryatel, W.H. Gourdin (pdf version available at https://e-reports-xt.llnl.gov/pdf/328839.pdf).
7. Advanced Optical Wireless Communication Systems, Shlomi Arnon, John Barry, George Karagiannidis, Robert Schober, and Murat Uysal, Cambridge University Press, 2012.
8. Optical Wireless Communications System and Channel Modelling, Z. Ghassemlooy W. Popoola S. Rajbhandari, CRC Press, 2019.

## 24-812-0904 Quantum Communication
## (Level 500)

Pre-requisite: 24-812-0404 Quantum Mechanics I & 24-812-0501 Quantum Mechanics II

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Analyze the principles of quantum tunnelling and its significance in quantum computing. | Analyze | 7 | 0 |
| CO2 | Identify basic applications of the Bloch sphere in visualizing qubit states. | Apply | 6 | 0 |
| CO3 | Apply knowledge of qubit metrics to analyze and interpret experimental results, such as spin relaxation time and decoherence time. | Apply | 6 | 0 |
| CO4 | Discuss the practical implications of utilizing specific qubit modalities in quantum computing applications. | Analyze | 8 | 0 |
| CO5 | Analyze quantum circuits for specific computational tasks, incorporating quantum gates and entanglement. | Analyze | 7 | 0 |
| CO6 | Evaluate the significance of DiVincenzo's criteria in assessing the feasibility and effectiveness of quantum computation systems. | Evaluate | 8 | 0 |
| CO7 | Describe the significance of the EPR paradox and density matrix formalism in quantum communication. | Understand | 9 | 0 |
| CO8 | Demonstrate an understanding of basic principles underlying quantum communication protocols. | Understand | 9 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | | 1 | | | | |
| CO2 | 3 | 2 | | 1 | | | | |
| CO3 | 3 | 2 | | 1 | | | | |
| CO4 | 3 | 2 | | 1 | | | | |
| CO5 | 3 | 2 | | 1 | | | | |
| CO6 | 3 | 2 | | 1 | | | | |
| CO7 | 3 | 2 | | 1 | | | | |
| CO8 | 3 | 2 | | 1 | | | | |

3-High; 2-Medium; 1-Low

Module I

Quantum tunnelling, Stern and Gerlach experiment, Bloch sphere representation, Qubit rotations, Projective measurements, The vocabulary of quantum computing, Classical computers, Qbits and usability, Noisy intermediate scale quantum technology.

Module II

Qbit Metrics: Spin relaxation time, Dephasing time, Decoherence time, Hann echo, Ramsay experiment, Gate time, Gate fidelity.

Qbit Modalities: Trapped ion qubit, Superconducting transmons, Topological qubits, Quantum dots, Dilution refrigerator.

Module III

Quantum circuits, Quantum gates, The compute stage, Quantum entanglement, No-cloning theorem, Quantum teleportation, Quantum interference, Phase kickback, DiVincenzo's criteria for quantum computation.

Module IV

EPR paradox, Density matrix formalism, Von Neumann entropy, Entangled photons, Quantum communication, quantum channel, Quantum communication protocols, RSA security.

**References**


1. Fundamentals of Quantum Computing: Theory and Practice, V Kasirajan, Spinger Switzerland, 2021.
2. Quantum Computation and Quantum Information, Michael A. Nielsen and Isaac L. Chuang, Cambridge University Press, 2010.
3. Quantum Information Theory and the Foundations of Quantum Mechanics, Christopher G. Timpson, Cambridge University Press, 2013.
4. Introduction to Topological Quantum Matter & Quantum Computation, Chetan Nayak, Steven H. Simon, Ady Stern, Michael Freedman, and Sankar Das Sarma, Cambridge University Press, 2013.

## 24-812-0905 Ultrafast Optics
## (Level 500)

Pre-requisites: 24-812-0601 Laser Physics & 24-812-0703 Non-Linear Optics

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Analyse the significance and applications of ultrashort laser pulses. | Analyze | 7 | 0 |
| CO2 | Demonstrate proficiency in Electric Field Autocorrelation and Cross-Correlation Measurements for pulse analysis. | Apply | 6 | 0 |
| CO3 | Evaluate advanced techniques like Frequency-Resolved Optical Gating for pulse characterization. | Apply | 6 | 0 |
| CO4 | Analyze the effects of Group Velocity Dispersion on pulse propagation and optical components. | Analyze | 8 | 0 |
| CO5 | Evaluate Ultrafast Nonlinear Optics phenomena, including Forced Wave Equation and Modulational Instability. | Analyze | 7 | 0 |
| CO6 | Analyze Pump–Probe techniques for time-resolved spectroscopy. | Evaluate | 8 | 0 |
| CO7 | Evaluate principles of Terahertz Time-Domain Electromagnetics, including pulse generation and spectroscopy. | Understand | 9 | 0 |
| CO8 | Analyze Acousto-optic Dispersive Filters, understanding their advantages in pulse shaping. | Analyze | 9 | 0 |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 |
|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 1 | | | |
| CO2 | 3 | 3 | 1 | 1 | | | |
| CO3 | 3 | 3 | 1 | 1 | | | |
| CO4 | 3 | 3 | 1 | 1 | | | |
| CO5 | 3 | 3 | 1 | 1 | | | |
| CO6 | 3 | 3 | 1 | 1 | | | |
| CO7 | 3 | 3 | 1 | 1 | | | |
| CO8 | 3 | 3 | 1 | 1 | | | |

3-High; 2-Medium; 1-Low

Module I

Introduction to ultrashort laser pulses: significance and application of ultrashort pulses, overview of ultrashort pulse generation techniques. Introduction to Ultrashort Pulse Generation Through Mode-Locking.

Solid-State Laser Mode-Locking Using the Optical Kerr Effect: Nonlinear Refractive Index Changes, Self-Amplitude Modulation, Self-Phase Modulation, and Group Velocity Dispersion, Additive Pulse Mode-Locking, Kerr Lens Mode-Locking

Module II

Ultrashort Pulse measurement method: Electric Field Autocorrelation Measurements, Electric Field Cross-Correlation Measurements and Spectral Interferometry. Correlation Measurements Using Second-Harmonic Generation, Chirped Pulses and Measurements in the Time–Frequency Domain. Frequency-Resolved Optical Gating and Pulse Measurements, Pulse Measurements Based on Frequency Filtering.

Module III

Group Velocity Dispersion, Dispersion of Optical Components, Measurements of Group Velocity Dispersion.

Ultrafast Nonlinear Optics: Forced Wave Equation in Frequency and Time Domain, SHG with pulse, three wave interaction, propagation equation for nonlinear refractive index media, Self-Phase modulation, pulse compression, Modulational instability, solitons and Higher order propagation effects.

Module IV

Fourier Transform Pulse Shaping, Direct Space-to-Time Pulse Shaping, Acousto-optic Dispersive Filters and their advantages. Chirp Processing and Time Lenses, Ultrashort-Pulse Amplification. Ultrafast Time-Resolved Spectroscopy: Degenerate Pump–Probe Transmission Measurements, Nondegenerate and Spectrally Resolved Pump–Probe. Generation and Measurement of Terahertz Pulses, Terahertz Spectroscopy and Imaging

**References**


1. Ultrafast Optics by Andrew Weiner (John Wiley & Sons, 2009) (Text).
2. Principles of Lasers by Orazio Svelto (5th ed., Springer, 2010).
3. Nonlinear Optics by Robert Boyd (3rd ed., Academic Press, 2008).
4. Ultrafast Optics by Franz X. Kärtner (from MIT course 6.638 offered in Fall 2008).

**24-812-0906 Plasma Physics**
**(Level 500)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Explain the concept of plasma parameters. | Understand | 6 | |
| CO2 | Analyse the dynamics of charged particle in Electric and magnetic field. | Analyze | 6 | |
| CO3 | Discuss the drift of charged particles under combinations of fields. | Understand | 8 | |
| CO4 | Explain the dynamics of charged particles under time varying fields. | understand | 8 | |
| CO5 | Illustrate the kinetic and fluid description of plasma. | Analyze | 8 | |
| CO6 | Explain plasma instabilities and its classification. | Understand | 8 | |
| CO7 | Discuss the technical application of plasma. | Understand | 8 | |
| CO8 | Explain the laser produced plasma and its diagnostics. | Understand | 8 | |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | | | | 1 | |
| CO2 | 3 | 3 | 1 | | | | 1 | |
| CO3 | 3 | 3 | 1 | | | | 1 | |
| CO4 | 3 | 3 | 1 | | | | 1 | |
| CO5 | 3 | 3 | 1 | | | | 1 | |
| CO6 | 3 | 3 | 1 | | | | 1 | |
| CO7 | 3 | 3 | 1 | | | | 1 | |
| CO8 | 3 | 3 | 1 | | | | 1 | |

3-High; 2-Medium; 1-Low

Module I

Plasma State: Definition of Plasma, concept of plasma temperature, Debye shielding, quasineutrality, plasma parameters, plasma approximation, natural existence of plasma, application of plasma, dynamics of charged particles in electro-magnetic fields.

Module II

Drift of charge particle under different combination of electric and magnetic field, crossed electric and magnetic field, homogeneous electric and magnetic field spatial and time varying electric and magnetic field.

Module III

Kinetic theory of Plasma, Vlasov equations, solution of linearized Vlasov equation, Langmuir waves, Ion-sound waves, wave-particle interaction and Landau damping. Boltzmann equation, Saha equation, Boltzmann's H Theorem.Maxwell velocity distribution conducting fluids, fundamental equation of magneto hydrodynamics (MHD), magnetic confinement, Plasma instabilities and classification.

Module IV

Thermonuclear fusion, Requirements for fusion plasmas- confinement, Tokamak fusion reactors, dusty plasma in laboratory and space, waves in dusty plasma. Laser plasma interaction, Inertial confinement, High-harmonic generation, Laser wakefield electron accelerator, X-ray laser.

**References**


1. Fundamentals of Plasma Physics, J A Bittencourt, Third Edition, Springer, New York, 2004 (Text).
2. Introduction to Plasma Physics and Controlled Fusion, Francis F Chen, Second Edition, Plenum, New York ,1984 (Text).
3. Fundamentals of Plasma Physics, Paul M Bellan, Cambridge University Press, 2006.
4. Introduction to Plasma Theory, D R Nicholson, John Wiley & Sons, New York, 1983.
5. The Physics of Laser Plasma Interaction, W L Kruer, Cambridge University Press, 1988.

**24-812-0907 Microscopic Techniques**
**(Level 500)**

| CO | CO Statement | CL | Class Hrs | Lab Hrs |
|---|---|---|---|---|
| CO1 | Understand the basic concepts of instrumentation of optical microscopy. | Understand | 7 | |
| CO2 | Evaluate the designs and specifications of different elements of an optical microscope. | Analyze | 8 | |
| CO3 | Interpret phase contrast, dark-field, and polarization microscopy. | Understand | 7 | |
| CO4 | Analyze confocal, two-photon, multi-photon and laser scanning microscopic techniques. | Analyze | 8 | |
| CO5 | Compare super-resolution microscopy techniques for enhanced resolution and application-specific selection. | Apply | 8 | |
| CO6 | Analyze classical resolution limits and apply super-resolution principles to specific microscopy techniques. | Analyze | 7 | |
| CO7 | Understand resolution, electron-matter interaction, and instrument limitations of electron microscopes. | Understand | 7 | |
| CO8 | Apply scanning probe microscopy basics, demonstrating understanding of electron tunneling, atomic forces, and their application on surfaces. | Apply | 8 | |
| | Total Number of Hours | | 60 | 0 |

CO-PSO Mapping

| CO\PSO | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 2 | 1 | 1 | 2 | |
| CO2 | 3 | 3 | 1 | 2 | 1 | 1 | 2 | |
| CO3 | 3 | 3 | 1 | 2 | 1 | 1 | 3 | |
| CO4 | 3 | 3 | 1 | 2 | 1 | 1 | 3 | |
| CO5 | 3 | 3 | 1 | 2 | 1 | 1 | 3 | |
| CO6 | 3 | 3 | 1 | 2 | 1 | 1 | 3 | |
| CO7 | 3 | 3 | 1 | 2 | 1 | 1 | 2 | |
| CO8 | 3 | 3 | 1 | 2 | 1 | 1 | 3 | |

3-High; 2-Medium; 1-Low

Module I

Optical components of a light microscope, aperture and image plane, Koehler illumination, microscope illuminators, filters, effect of light on living cells, designs and specifications of objective lenses, condensers, oculars, microscope slides and cover slips.

Diffraction image of a point source of light, Abbe's theory of image formation in the microscope, numerical aperture, spatial resolution, depth of field and depth of focus, optimizing the microscope image.

Module II

Phase contrast microscopy: the behaviour of waves from phase objects in bright-field microscopy, the role of differences in optical path lengths, optical design of the phase contrast microscope, interpreting the phase contrast image.

Dark-field microscopy: theory, image interpretation

Polarization microscopy: optics of the polarizing microscope, retardation plates, Sénarmont compensator, Brace-Koehler compensator.

Fluorescence Microscopy: physical basis of fluorescence, properties of fluorescent dyes, autofluorescence of endogenous molecules, arrangement of filters and the epi-illuminator, objective lenses and spatial resolution.

Confocal microscopy: optical principle of confocal imaging, advantages of confocal laser scanning microscopy.

Two- and multi-photon laser scanning microscopy.

Module III

Super resolution microscopy: classical resolution limit, near-field optical microscopy, $I^5M$ microscopy, 4Pi microscopy, stimulated emission depletion (STED) microscopy, structured illumination spectroscopy, photoactivated localization microscopy (PALM), stochastic optical reconstruction microscopy (STORM), and fluorescent photoactivation localization microscopy (FPALM).

Module IV

Transmission and scanning electron microscopy: use of electrons for microscopy, resolution, interaction of electron with matter, depth of field and depth of focus, limitations of TEM, STEM, basic TEM instrumentation.

Scanning probe microscopy: basic principles, electron tunnelling, principles of atomic forces, theory of scanning tunnelling microscopy, metal and semiconductor surfaces.

**References**


2. Fundamentals of Light Microscopy and Electronic Imaging, Douglas B. Murphy and Michael W. Davidson, second edition, Wiley-Blackwell, 2013.
3. Transmission Electron Microscopy: A Textbook for Materials Science, David B. Williams and C. Barry Carter, Springer; 2nd edition, 2009.
4. https://zeiss-campus.magnet.fsu.edu/articles/superresolution/introduction.html.
5. Super resolution microscopy, Udo J. Birk, Wiley-VCH, 2017.
6. https://www.frontiersin.org/articles/10.3389/fchem.2021.746900/full.
7. Super resolution optical microscopy: The quest for enhanced resolution and contrast, Barry R. Masters, Springer Series in Optical Sciences, 2020.
8. Scanning probe microscopy and spectroscopy: theory, techniques, and applications second edition, edited by Dawn A. Bonnell, Wiley-VCH, 2001.