## Programme Outcomes

1. To create, apply, and disseminate knowledge of physics in theoretical and experimental domains under different specializations.
2. To encourage creative thinking and problem-solving capabilities through tutorials.
3. To encourage research culture, provide research ambience and develop related technical proficiency.
4. To equip the students to use computers as a tool for scientific investigations/understanding.
5. Demonstrate highest standards of Actuarial ethical conduct and Professional Actuarial behaviour, critical, interpersonal and communication skills as well as a commitment to life-long learning.

## Programme Specific Outcomes

1. Student are able to apply the knowledge of core concepts of physics in semester exams, in the NET, SET and GATE, national level exams as well as in the research level projects work which is suitable to communicate/present further in workshops and conferences.
2. The students learn to carry out experiments in basic as well as certain advanced areas of physics such as lasers, spectroscopy, electronics, condensed matter physics, nanoscience.
3. The students gain hands-on experience to work in applied fields.
4. Through the research cultural of the department and skills acquired therein, students are capable of sustaining subsequent academic progression inside the country and overseas as well.
5. Regular practice of Self-declaration of the authenticity, uniqueness of project work, plagiarism check, and departmental scrutiny etc. inculcates the ethics in the research publication.

## Courses and Credit Index

### Semester -VII

| Sr. No. | Course Title and Code | Credit Structure | | | |
|---|---|---|---|---|---|
| | | L | T | P/R | C |
| | **Four Compulsory Theory Papers** | | | | |
| 1. | Mathematical Physics (B010701T) | 3 | 1 | 0 | 4 |
| 2. | Classical Mechanics (B010702T) | 3 | 1 | 0 | 4 |
| 3. | Electrodynamics and Relativity (B010703T) | 3 | 1 | 0 | 4 |
| 4. | Quantum Mechanics – I (B010704T) | 3 | 1 | 0 | 4 |
| **Minor elective Course from other faculty** | | | | | |
| 5. | *Minor elective course from other department/faculty | | | | 4 |
| | **Lab and Dissertation Courses** | | | | |
| 6. | General Lab. (B010705P) or Electronics Lab. (B010706P) | 0 | 0 | 8 | 4 |
| 7. | Dissertation Phase 1: Literature Survey and to identify the problem (B010707R) | 0 | 0 | 8 | 4 |
| **Total credits earned in Semester-I ΣCi** | | | | **24 or 28#** | |
| **Minor elective (value added) course for students of other departments** | | | | | |
| 8. | $Fundamentals of Physics (B010708M) | 4 | 0 | 0 | 4 |

### Semester – VIII

| Sr. No. | Course Title and Code | Credit Structure | | | |
|---|---|---|---|---|---|
| | | L | T | P/R | C |
| | **Four Compulsory Theory Papers** | | | | |
| 1. | Quantum Mechanics – II (B010801T) | 3 | 1 | 0 | 4 |
| 2. | Statistical Mechanics (B010802T) | 3 | 1 | 0 | 4 |
| 3. | Solid State Electronics (B010803T) | 3 | 1 | 0 | 4 |
| 4. | Atomic and Molecular Physics (B010804T) | 3 | 1 | 0 | 4 |
| **Minor Course from other faculty** | | | | | |
| 5. | *Minor Course from other department/faculty | | | | 4 |
| | **Lab. and Dissertation Courses** | | | | |
| 6. | General Lab. (B010806P) or Electronics Lab. (B010805P) | 0 | 0 | 8 | 4 |
| 7. | Dissertation Phase 1: Data Collection on the Problem (B010807R) | 0 | 0 | 8 | 4 |
| **Total credits earned in Semester-II ΣCi** | | | | **24 or 28#** | |
| **Minor elective (value added) course for students of other departments** | | | | | |
| 8. | $Frontiers of Physics (B010808M) | 4 | 0 | 0 | 4 |

**Semester – IX**

| Sr. No. | Course Title and Code | Credit Structure | | | |
|---|---|---|---|---|---|
| | | L | T | P/R | C |
| | **Two Compulsory Theory Papers** | | | | |
| 1. | Solid State Physics (B010901T) | 3 | 1 | 0 | 4 |
| 2. | Nuclear and Particle Physics (B010902T) | 3 | 1 | 0 | 4 |
| | **Two Theory Papers from any of the three Specialization** | **Credit Structure for EACH PAPER** | | | |
| 3. | (i) Analog & Digital Electronics (B010903T),<br>(ii) Laser Spectroscopy (B010905T) **or**<br>(iii) Condensed Matter Physics-I (B010907T) | 3 | 1 | 0 | 4 |
| 4. | (i) Microwaves (B010904T),<br>(ii) Electronic Spectra of Diatomic Molecules (B010906T) **or**<br>(iii) Condensed Matter Physics-II (B010908T) | 3 | 1 | 0 | 4 |
| | **One Lab. Course from the chosen specialization and Dissertation** | | | | |
| 5. | (i) Electronics Lab. (B010909P),<br>(ii) Spectroscopy Lab. (B010910P) **or**<br>(iii) Condensed Matter Physics Lab. (B010911P) | | | 8 | 4 |
| 6. | Dissertation Phase 3: Data Analysis (B010912R) | | | 8 | 4 |
| | **Total credits earned in Semester-III ΣCi** | | | | **24** |

**Semester – X**

| Sr. No. | Course Title and Code | Credit Structure | | | |
|---|---|---|---|---|---|
| | | L | T | P/R | C |
| | **One Compulsory Theory Paper** | | | | |
| 1. | Experimental Techniques and Control Systems (B011001T) | 3 | 1 | 0 | 4 |
| | **One elective paper from three papers** | | | | |
| 2. | (i) Computational Physics with Python (B011002T) | 3 | 1 | 0 | 4 |
| | (ii) Advanced Electrodynamics and Second Quantization (B011003T) **or** | 3 | 1 | 0 | 4 |
| | (iii) Group Theory (B011004T) | 3 | 1 | 0 | 4 |
| | **Two Theory Papers from any of the three Specialization** | **Credit Structure for EACH PAPER** | | | |
| 3. | (i) Microprocessor (B011005T),<br>(ii) Advanced Atomic Spectroscopy (B011007T) **or**<br>(iii) Condensed Matter Physics-III (B011009T) | 3 | 1 | 0 | 4 |
| 4. | (i) Physics of Semiconductor Devices (B011006T),<br>(ii) IR & Raman Spectra of Polyatomic molecules (B011008T) **or**<br>(iii) Condensed Matter Physics-IV (B011010T) | 3 | 1 | 0 | 4 |
| | **One Lab. Course from the chosen specialization and Dissertation** | | | | |
| 5. | (i) Electronics Lab. (B011011P),<br>(ii) Spectroscopy Lab. (B011012) **or**<br>(iii) Condensed Matter Physics Lab. (B011013P) | | | 8 | 4 |

| | | | | | |
|---|---|---|---|---|---|
| 6. | Dissertation Phase 4: Final Report submission and Presentation. (B011014R) | | | 8 | 4 |
| **Total credits earned in Semester-III ΣCi** | | | | | **24** |

*** -** Students of M. Sc. (Physics) programme have to opt and complete one minor course of 4 credits offered by other departments of other faculties in Semester VII or VIII.
# - Credit of one minor course is accounted for.
$ - Students of other departments can opt for minor (value added) courses offered at our department.
Students will earn total of 52 credits (24+28 or 28+24) in first year and 48 credits (24+24) in final (second) year of M. Sc. (Physics) programme.

**A. Rules for Completion of Course:**

| Sr. No. | Grades Scores in Individual Courses | Status of Promotion | Eligibility of Completion of Course |
|---|---|---|---|
| 1. | 'P' or above in all courses/papers | Passed | _ _ _ |
| 2. | Below 'P' in one or two Courses/papers | Eligible for SE | Second Exam. in which scored below 'P' Grade |
| 3. | Below 'P' in more than two Courses | Failed* | All courses as Ex-student for the semester |

* The pass marks in each semester shall be (i) 36% marks in each theory paper, and (ii) 36% marks in practical examination examinations.

**B. Grades and Grade Points:**

| Sr. | Percentage of Marks Obtained | Letter Grade | Grade Point (Gi) | Classification |
|---|---|---|---|---|
| 1. | 90% or above | O | 10 | Outstanding |
| 2. | 80% or above but below 90% | A+ | 9 | Excellent |
| 3. | 70% or above but below 80% | A | 8 | Very Good |
| 4. | 60% or above but below 70% | B+ | 7 | Good |
| 5. | 50% or above but below 60% | B | 6 | Above Average |
| 6. | 40% or above but below 50% | C | 5 | Average |
| 7. | 36% or above but below 40% | P | 4 | Passed |
| 8. | Below 36% | F | 0 | Failed |
| 9. | Absent | Ab | 0 | Absent |

**C. Formulae:** $Cpc = Ci \times Gi$; $SGPA = {\Sigma Cpc}/{\Sigma Ci}$; $CGPA = {\Sigma(SGPA \times \Sigma Ci)}/{\Sigma(\Sigma Ci)}$

**D. Abbreviations used in Grade Card:**
(Ci) Credit Index; (Gi) Grade Point; (Cpc) Credit Points in the Course;
(SGPA) Semester Grade Point Average; (CGPA) Consolidated Grade Point Average

**E. The Multiplication factor for conversion of obtained CGPA into obtained percentage will be 9.5.**

**F. Duration for completion of the Programme will be "Duration of the Programme + 2 years".**

| Programme: **M. Sc.** | Year: I | Semester: VII |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B010701T** | Course Title: **Mathematical Physics** | |

**Course Outcomes (COs)**

After the completion of the course, students will be/able to

1. Master of the basic elements of complex mathematical analysis and be able to derive Cauchy integral theorem and Cauchy integral formula and find Taylor and Laurent series expansion of functions of complex variable and understand the calculus of residue and evaluate some typical definite integral using the method of contour integration.
2. Solve differential equations that are common in physical sciences and apply integral transforms to solve mathematical problems of interest in Physics
3. Understand and solve the problems based on special functions like Hermite, Bessel, Laguerre and Legendre functions.
4. Understand how to use special functions in various physics problem
5. Understand fundamentals and applications of Fourier series, Fourier and Laplace transforms, their inverse transforms etc.

| Credit: **4** | Core Compulsory |
|---|---|
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Linear Differential Equations: Second order linear differential equations; Regular, regular singular and singular points; series expansion method. | 9 |
| **II** | Complex Analysis: Analytic functions, Cauchy-Riemann equations, Cauchy's theorem, Cauchy's Integral formula, Laurent series, Poles, Residue theorem, Evaluation of integrals. | 9 |
| **III** | Special Functions: Bessel, Legendre, Hermite and Laguerre differential equations with properties of their solutions. | 9 |
| **IV** | Integral transforms: Laplace transform, Fourier theorem, Fourier transforms. | 9 |
| **V** | Dirac delta function and Green function: Green function for Laplace operator, Solution of Poisson's equation, Inhomogeneous Wave equation and applications. | 9 |

**Suggested Readings**

1. Mathematical methods for Physicists, George Arfken, Hans Weber and Harris, 4th edition, Academic Press Inc. 1995.
2. Advanced Engineering Mathematics: Erwin Kreyszig
3. Mathematical Physics by H.K. Dass, S. Chand Publications, 5th edition, 2017.
4. Schaum's Outlines Complex Variables by M. R. Spiegel, Mc-G
5. Mathematical Physics by B.S. Rajput
6. Mathematical Physics, AK Ghatak, Trinity Press-Laxmi Publications, 1st Edition, 1995.

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics

| |
|---|
| 2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html<br>3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx<br>4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/<br>**5.** edX, https://www.edx.org/course/subject/physics |
| **Course Prerequisites** |
| Physics as a major subject in B. Sc. |

| | | |
|---|---|---|
| Programme: **M. Sc.** | Year: I | Semester: VII |
| Subject: **Physics** | | |
| Course Code: **B010702T** | Course Title: **Classical Mechanics** | |
| **Course Outcomes (COs)**<br>After the completion of the course, students will be/able to | | |
| 1. Develop the skills to understand and use the Lagrangian and the Hamiltonian formalism for solving the equations of motion for any reasonable mechanical system.<br>2. Understand the Canonical Transformations.<br>3. Understand the Hamilton – Jacoby Theory.<br>4. Gain the familiarity with basic ideas of motion in small oscillations and normal modes. | | |
| Credit: **4** | Core Compulsory | |
| Max. Marks: 25+75 | Min. Passing Marks: | |
| Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0 | | |

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Variational Principles and Lagrange's Equations: Hamilton's principle, Calculus of variations, Lagrange's equations, Conservation Theorems and symmetry properties. | 9 |
| **II** | Hamiltonian formalism: Legendre transformations and the Hamiltonian Equations of Motion, Cyclic coordinates. | 9 |
| **III** | Canonical Transformations: Canonical transformations, Poisson Bracket | 9 |
| **IV** | Hamilton – Jacoby Theory: Hamiltonian Jacoby equations; Hamiltonian Jacoby theory, geometrical optics and wave mechanics | 9 |
| **V** | Small oscillations and normal modes: Small oscillations about a stable equilibrium, Normal modes and their frequencies, Langrangian and Hamiltonian formalism of Classical fields. | 9 |
| | **Suggested Readings** | |
| | 1. Classical Mechanics: H Goldstein<br>2. Classical Mechanics: J. C. Upadhayay<br>3. Classical Mechanics: John R. Taylor<br>4. Classical Mechanics: David J. Morin<br>5. Classical Mechanics: N C Rana and P S Joag | |
| | **Suggested Digital Platforms/Web Links** | |

| |
|---|
| 1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics<br>2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html<br>3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx<br>4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/<br>5. edX, https://www.edx.org/course/subject/physics |
| **Course Prerequisites** |
| Physics as a major subject in B. Sc. |

| | | |
|---|---|---|
| Programme: **M. Sc.** | Year: I | Semester: VII |
| Subject: **Physics** | | |
| Course Code: **B010703T** | Course Title: **Electrodynamics and Relativity** | |
| **Course Outcomes (COs)**<br>After the completion of the course, students will (/be/able to) | | |
| 1. have basic understanding of tensor analysis.<br>2. explain the fundamental concepts of geometry of space time in special relativity and the principle of causality.<br>3. have knowledge about Lorentz group and electromagnetic field tensor, perform Lorentz transformation of electric and magnetic fields.<br>4. derive equation of motion of a charge particle and determine force on it when it being in static and uniform electric fields.<br>5. familiar with the fundamental features and concepts of transmission lines and waveguides and their applications. | | |

| | |
|---|---|
| Credit: **4** | Core Compulsory |
| Max. Marks: 25+75 | Min. Passing Marks: |
| Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0 | |

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Tensor analysis: General coordinate transformation; contravariant, covariant and mixed tensors; metric tensor; raising and lowering of indices; contraction of indices; Pseudo-tensors. | 9 |
| **II** | Minkowsky space and Lorentz transformations: Geometry of space-time in Special Relativity; Minkowsky metric; Light cone and principle of causality; Invariance of Minkowsky metric under Lorentz transformations; Lorentz group; Proper, improper and orthochronous transformations. | 9 |
| **III** | Covariant formulation of electromagnetism: Charge-current density four-vector; Scalar and Vector potentials; Gauge invariance; Electromagnetic potential four-vector; Electromagnetic field tensor; Lorentz | 9 |

| | | |
|---|---|---|
| | transformation of electric and magnetic fields; Invariants of the electromagnetic field. | |
| **IV** | Electromagnetic field of a charge moving with constant velocity, Covariant form of Lorentz force law; Dynamics of charged particles in static and uniform electric fields. | 8 |
| **V** | Guided electromagnetic waves: Transmission Lines and Wave Guides, Modes in a rectangular wave guide, Cavity resonators. | 10 |

**Suggested Readings**

1. The Feynman Lectures on Physics, Vol. II: Mainly Electromagnetism and Matter, Richard Feynman, Robert B. Leighton, Matthew Sands (Pearson Education India, 2012)
2. Schaum's Outline of Vector Analysis, Murray R. Spiegel (McGraw-Hill Education)
3. Introduction to Electrodynamics, $4^{th}$ edition, D. J. Griffiths (Pearson Education India, 2015)
4. A first Course in General Relativity, $2^{nd}$ edition, Bernard Schutz (Cambridge University Press, 2009)
5. Field and Wave Electromagnetics, $2^{nd}$ edition, David K. Cheng (Pearson Education India, 2014)
6. Introduction To Electromagnetic Theory, $1^{st}$ edition, Ram Kripal (Booksclinic Publishing, 2021)

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx
4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/
5. edX, https://www.edx.org/course/subject/physics

**Course Prerequisites**

Physics as a major subject in B. Sc.

| Programme: **M. Sc.** | Year: I | Semester: VII |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B010704T** | Course Title: **Quantum Mechanics I** | |

**Course Outcomes (COs)**

After the completion of the course, students will (/be/able to)

1. Gain knowledge of dimensionality of space and understanding the Dirac's notation used for physical state of a system. Representation of states, operators, and its finding probabilities in matrix form.
2. Learn the concept of quantum state measurement. Grasp the basic concept of uncertainty principle.
3. Develop a clear understanding of each class of representations.
4. Analyse the Harmonic Oscillator problem using Bra-Ket notation.
5. Learn the quantum mechanical algebra of angular momentum and calculation of Clebsch-Gordan coefficients.

| Credit: **4** | Core Compulsory |
|---|---|
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Hilbert Space, Dirac's Bra & Ket Notations, Observables as Operators, Projection operators, Hermiticity of Operators, Orthonormality and Completeness Relation, Matrix representation of Kets, Bras and operators. Wave-functions in Coordinate and Momentum Representations. | 12 |
| **II** | Elementary ideas of Measurement in Quantum Mechanics, Commutators and Heisenberg uncertainty principle, General proof of Uncertainty Principle. | 6 |
| **III** | Time Evolution of the System's state, Schrödinger, Heisenberg and Dirac Representations. | 9 |
| **IV** | Matrix Theory of Harmonic Oscillator, Time Development of Harmonic Oscillator. | 9 |
| **V** | Stern-Gerlach Experiment and Spin, Orbital Angular Momentum, Angular Momentum Algebra, Addition of Angular Momenta, Clebsch-Gordan Coefficients, Explicit Addition of Angular Momentum 1/2 with Angular Momenta 1/2 and 1. | 9 |

**Suggested Readings**

1. Quantum Mechanics: Concept and Applications by Nouredine Zettili
2. Advance Quantum Mechanics by B. S. Rajput
3. Advance Quantum Mechanics by J. J. Sakurai
4. Principles of Quantum Mechanics by P. A. M. Dirac

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html

| |
|---|
| 3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx<br>4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/<br>**5.** edX, https://www.edx.org/course/subject/physics |
| **Course Prerequisites** |
| Physics as a major subject in B. Sc. |

| Programme: **M. Sc.** | Year: I | Semester: VII |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B010705P** | Course Title: **General Lab** | |
| **Course Outcomes (COs)** | | |

In this course the experiments are designed to give understanding of heat, magnetism, electricity and optics experiments.

1. By determining the velocity of ultrasonic waves in a liquid at different temperatures using Ultrasonic interferometer, students build understanding of Ultrasonics as a non-destructive testing tool for measuring mechanical and elastic properties of solid and liquid materials.
2. Optical Properties of Quartz experiment helps the students not only in understanding the behaviour of light passing through different axes of crystal but also in understanding birefringence and chirality of quartz crystal.
3. Determination of Stefan's constant by electrical method helps students to clarify the concept of black body radiation.
4. Fabry-Perot Interferometer and Edser-Butler fringes experiments make students aware of different optical interference techniques being used in the field of Physics.
5. Fresnel's Formula and Study of Total Internal Reflection experiments help the students to understand the refraction and reflection phenomena.
6. By Curie Temperature experiment and Quincke's tube method experiment, students learn about magnetic properties of materials.
7. Iodine Absorption spectra experiment helps students learn about absorption spectra and associated parameters and properties of Iodine and thus other materials.

| Credit: **4** | Core Compulsory |
|---|---|
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 0-0-8-0

**List of Experiments**

1. Concave Grating, Hg Source Arc
2. Optical Properties of Quartz
3. Cornu's fringes
4. Fabry-Perot Interferometer
5. Edser-Butler Fringes
6. Fresnel's Formula
7. Study of Total Internal Reflection
8. Curie Temperature
9. Quincke's Tube method
10. Iodine Absorption Spectra
11. Stefan's Constant
12. Ultrasonic Interferometer – Variation of velocity with temperature
13. Forbidden Energy Gap of semiconductors
14. Laser Intensity diffraction pattern of different objects
15. Fourier Analysis

**Suggested Readings**

| |
|---|
| 1. The Feynman Lectures on Physics, Vol. II: The New Millennium Edition: Mainly Electromagnetism and Matte, Richard P. Feynman, Robert B. Leighton, Matthew Sands (Pearson Education India, 2012)<br>2. Optics, Ajoy Ghatak (McGraw Hill, 2020)<br>3. Fundamentals of Optics, Francis Jenkins, Harvey White (McGraw Hill Education, 2017)<br>4. Introduction to Modern Optics, Grant R. Fowles (Dover Publications Inc, 1990) |
| **Course Prerequisites** |
| Physics as a major subject in B. Sc. |

| | | |
|---|---|---|
| Programme: **M. Sc.** | Year: I | Semester: VII |
| Subject: **Physics** | | |
| Course Code: **B010706P** | Course Title: **Electronics Lab** | |
| **Course Outcomes (COs)** | | |
| 1. The students learn to design and study the amplifiers in CB, CE and CC configurations.<br>2. The students gain knowledge on the variation of characteristics and constants of BJT, its Bias-stabilization and Band gap of semiconductor diodes.<br>3. The students are able to perform amplitude modulation and demodulation.<br>4. The students gain skills to design the Phase-Shift Oscillator, Tuned Collector Oscillator and Astable multivibrator.<br>5. The students learn the concept of Negative feedback. | | |
| Credit: **4** | Core Compulsory | |
| Max. Marks: 25+75 | Min. Passing Marks: | |
| Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 0-0-8-0 | | |
| | **List of Experiments** | |
| | **1.** Band Gap of Ge and Si Diode<br>**2.** Negative Feedback<br>**3.** Modulation and Demodulation<br>**4.** Astable Multivibrator<br>**5.** 555 Timer IC<br>**6.** Field Effect Transistor (FET)<br>**7.** Silicon Controlled Rectifier (SCR)<br>**8.** Uni Junction Transistor (UJT)<br>**9.** Phase Shift Oscillator (PSO)<br>**10.** Hartley Oscillator<br>**11.** Tuned Collector Oscillator (TCO)<br>**12.** Design and Study of CE Amplifier | |
| **Suggested Readings** | | |
| 1. Electronic Devices and Circuits by Millman & Halkias.<br>2. Electronic Fundamentals and Applications by John D. Ryder.<br>3. Physics of Semiconductor Devices by S. M. Sze.<br>4. Principles of Electronics by V. K. Mehta | | |
| **Course Prerequisites** | | |
| Physics as a major subject in B. Sc. | | |

| Programme: **M. Sc.** | Year: I | Semester: VII |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B010707R** | Course Title: **Dissertation Phase 1** | |
| **Course Outcomes (COs)**<br>After the completion of the course, students will (/be/able to) | | |
| 1. Identity relevant sources and literature related to the chosen field of study.<br>2. Analyse the literature to identify gaps, inconsistencies, or areas that require further exploration.<br>3. Develop a deep understanding of the current state of research in the chosen area.<br>4. Define a focused research problem that addresses a specific gap or challenge in the field.<br>5. Frame specific research questions or hypotheses that guide the direction of the dissertation. | | |
| Credit: **4** | Core Compulsory | |
| Max. Marks: 100 | Min. Passing Marks: | |
| Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 0-0-0-8 | | |
| Unit | Topics | **No. of Lectures** |
| **NA** | **Literature Survey and to identify the problem** | **NA** |
| **Suggested Readings** | | |
| 1. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, J. W. Creswell (SAGE Publications, 2014)<br>2. The Craft of Research, Wayne C. Booth, Gregory Colomb, Joseph M. Williams, William Fitzgerald (University of Chicago Press, 2008)<br>3. As per the field of the project. | | |
| **Suggested Digital Platforms/Web Links** | | |
| 1. Google Scholar (https://scholar.google.com/)<br>2. ScienceDirect (https://www.sciencedirect.com/)<br>3. Scopus (https://www.elsevier.com/en-in/solutions/scopus)<br>4. Web of Science (http://webofscience.com/wos/woscc/basic-search) | | |
| **Course Prerequisites** | | |
| Physics as a major subject in B. Sc. | | |

| Programme: **M. Sc.** | Year: I | Semester: VII |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B010708M** | Course Title: **Fundamentals of Physics** | |

**Course Outcomes (COs)**

After the completion of the course, students will (/be/able to)

1. To appreciate Physics as a fundamental science and to understand the working of the Universe around us.
2. To develop a scientific temper.

| Credit: **4** | Minor Elective |
|---|---|
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Historical Development of Physics; Classification of physics in terms of Length scales, Time scales and Energy scales. | 9 |
| **II** | Evolution of universe and formation of stars. Newton's law of Gravitation; Planetary motion and Kepler's laws; Galilean relativity and concept of inertial frames. Einstein's theory of special relativity. | 9 |
| **III** | Failure of classical ideas with examples of blackbody spectrum and Photoelectric effect; Heisenberg's Uncertainty Principle; Wave-particle duality. Double-slit experiment, Stern-Gerlach experiment. | 9 |
| **IV** | Concepts of discrete energy levels and spin. Elementary ideas of Schrodinger's Wave mechanics. Relation between Spin and Statistics | 9 |
| **V** | Bose-Einstein and Fermi-Dirac statistics, and Maxwell-Boltzmann statistics as classical limit. Elementary Particles (classification, quantum numbers) and Fundamental Interactions (classification, range, strength). | 9 |

**Suggested Readings**

1. The Feynman Lectures on Physics vol. I, II & III, Richard Feynman, Robert B. Leighton, Matthew Sands (Pearson Education India, 2012)
2. Remarkable Physics: From Galileo to Yukawa, Ioan James (Cambridge University Press, 2004)
3. University Physics vol. I, II, III, William Moebs, Samuel J. Ling, Jeff Sanny (12th Media Services, 2016)

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx

**Course Prerequisites**

Open to all.

| Programme: **M. Sc.** | Year: I | Semester: VIII |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B010801T** | Course Title: **Quantum Mechanics II** | |

**Course Outcomes (COs)**

After the completion of the course, students will (/be/able to)

1. understand the concept of perturbation and calculation for eigen value.
2. learn application of time – dependent perturbation theory for transition probability.
3. have basic understanding of non-relativistic quantum scattering.
4. be able to analyze the Klein-Gordon and explain problems arising while dealing with it.
5. be able to explain how Dirac addressed problems that occurred in the case of Klein Gordon equation.
6. be able to perform solutions of Klein-Gordan and Dirac equations for free particle.

| Credit: **4** | Core Compulsory |
|---|---|
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Time-Independent Perturbation Theory and Applications, Variational Method, WKB Method. | 9 |
| **II** | Time-Dependent Perturbation Theory, Constant and Harmonic Perturbation, Transition probabilities, Fermi's Golden Rule. | 9 |
| **III** | Elementary theory of Scattering: Phase shifts, Method of partial waves, Born approximation. | 9 |
| **IV** | Klein Gordon Equation and Free Particle, Solution, Dirac Equation, Dirac Matrices, Covariance of Dirac Equation & Bilinear Covariant. | 9 |
| **V** | Solution for a Free Particle, Negative Energy states and Hole Theory, Spin, Position Operator. | 9 |

**Suggested Readings**

1. Introduction to Quantum Mechanics by D. J. Griffiths
2. Modern Quantum Mechanics by J. J. Sakurai
3. Quantum Mechanics: Concept and Applications by Nouredine Zettili
4. An Introduction to Relativistic Quantum Field Theory by S. S. Schweber
5. Quantum Mechanics, L. I. Schiff, Mc-Graw Hill
6. Relativistic Quantum Mechanics, James D. Bjorken and Sidney D. Drell (Tata McGraw Hill Education, 2013)

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx
4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/

**Course Prerequisites**

| |
|---|
| Physics as a major subject in B. Sc. |

| Programme: **M. Sc.** | Year: I | Semester: VIII |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B010802T** | Course Title: **Statistical Mechanics** | |
| **Course Outcomes (COs)**<br>After the completion of the course, students will (/be/able to) | | |
| 1. Gain knowledge of dimensionality of space and understanding the Dirac's notation used for physical state of a system. Representation of states, operators, and its finding probabilities in matrix form.<br>2. Learn the concept of quantum state measurement. Grasp the basic concept of uncertainty principle.<br>3. Develop a clear understanding of each class of representations.<br>4. Analyse the Harmonic Oscillator problem using Bra-Ket notation.<br>5. Learn the quantum mechanical algebra of angular momentum and calculation of Clebsch-Gordan coefficients. | | |
| Credit: **4** | Core Compulsory | |
| Max. Marks: 25+75 | Min. Passing Marks: | |
| Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0 | | |

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | A review of classical ensemble theory, Liouville's equations, Partition function and thermodynamic quantities of different systems such as Perfect Gas, Harmonic Oscillators. Fluctuation in energy in canonical ensemble and concentration in Grand Canonical ensemble. | 9 |
| **II** | Quantum Ensemble Theory: Density operator, Quantum Liouville's equation. Density operator for equilibrium microcanonical, canonical, and grand-canonical ensembles. Calculation of grand partition function and distribution function, Specific heat of solids. Pauli paramagnetism | 10 |
| **III** | Grand potential, FD and BE distribution in Grand Canonical ensemble Degenerate Bose Gas, Momentum Condensation, Liquid He II, Two fluid theory, Superfluidity. | 9 |
| **IV** | Degenerate FD Gas, Conduction Electrons in a Metal, Fluctuations, One dimensional Random walk, Gaussian Distribution. | **7** |
| **V** | Random processes, Markoff process, Langevin Equation, Correlation functions, Fluctuations Dissipation Theorem, Weiner-Khintchine theorem, Nyquist theorem, Conditional probability, Fokker Plank Equation, Brownian motion. | 10 |

**Suggested Readings**

1. Fundamentals of Statistical and Thermal Physics, F. Reif, Levant Kolkata, (2010).
2. Statistical Mechanics, K. Huang, 2nd ed., Wiley India, Delhi, (2009).
3. Statistical Mechanics, R. K. Pathria and P. D. Beale, 3rd Edition, Elsevier, Oxford, (2011).
4. Statistical Physics of Particles, M. Karder, Cambridge University Press, Cambridge, (2007).

5. Statistical Physics, L. D. Landau and E. M. Lifshitz, Part 1, Volume 5, Pergamon Press, New York, (1980).

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx
4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/
5. edX, https://www.edx.org/course/subject/physics

**Course Prerequisites**

Physics as a major subject in B. Sc.

| Programme: **M. Sc.** | Year: I | Semester: VIII |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B010803T** | Course Title: **Solid State Electronics** | |

**Course Outcomes (COs)**

After the completion of the course, students will (/be/able to)

1. Understand the fundamental designing and concepts of different types of Semiconductors, filters and regulators and characteristics of devices like PNP, and NPN etc.
2. Understand the working mechanism and circuit components of FETs and other circuit elements.
3. Understand the concept of feedback amplification and different class of negative feedback amplifiers.
4. Develop the understanding on power and radio frequency amplifiers and study on different circuit elements.

| Credit: **4** | Core Compulsory |
|---|---|
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | P-N Junction Diode: Rectifier with LC Filter, Electronic regulator. Bipolar Junction Transistors: h-parameters, inter conversion in different configurations, low frequency transistor amplifier. | 9 |
| **II** | Field Effect Transistors: Small signal model and dynamic parameters, CS and CD amplifiers. Multistage Amplifiers: BJT at high frequencies, frequency response of gain and phase shift, frequency response of RC coupled amplifier. | 9 |
| **III** | Feedback Amplifiers and Oscillators: Different negative feedback amplifiers, stability and Nyquist criteria, sinusoidal oscillators, phase shift and Wien's bridge oscillators, astable multivibrator. | 9 |

| | | |
|---|---|---|
| **IV** | Power and Radio Frequency Amplifier: Large signal amplifier and distortions, Push-pull amplifier. | 9 |
| **V** | Modulation: Frequency and phase modulation, frequency modulation Demodulation: Frequency changing and tracking. | 9 |

**Suggested Readings**

1. Electronic Devices and Circuits by Millman & Halkias.
2. Electronic Fundamentals and Applications by John D. Ryder.
3. Physics of Semiconductor Devices by S. M. Sze.
4. Principles of Electronics by V. K. Mehta.
5. Electronic Devices and Circuits, Jitendra Kumar, A. K. Tiwari and Devraj Singh (Narosa Publishing House, 2015)

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx
4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/
5. edX, https://www.edx.org/course/subject/physics

**Course Prerequisites**

Physics as a major subject in B. Sc.

| | | |
|---|---|---|
| Programme: **M. Sc.** | Year: I | Semester: VIII |
| Subject: **Physics** | | |
| Course Code: **B010804T** | Course Title: **Atomic and Molecular Physics** | |

**Course Outcomes (COs)**

After the completion of the course, students will (/be/able to)

1. Understand and explain the hydrogen and helium atomic spectrum
2. Recognize the spectroscopy of many electrons atomic systems and hyperfine splitting of spectral lines
3. Understand the rotational and vibrational spectra of diatomic molecule.
4. Understand the Raman spectra.

| | |
|---|---|
| Credit: **4** | Core Compulsory |
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Quantum states of an electron in an atom, Spectrum of Hydrogen and Helium atom, fine structure Spectra of Alkali atoms; energy level diagrams, Sharp, Principal, Diffuse and fundamental series. | 9 |
| **II** | Width of spectral lines, X-ray spectroscopy, Spectroscopic terms; LS & JJ couplings, Hyperfine structure | 9 |

| | | |
|---|---|---|
| **III** | Zeeman, Paschen Back & Stark effect, Electron spin resonance, Nuclear magnetic resonance, chemical shift | 9 |
| **IV** | Spectra of Diatomic Molecules Rotational Spectra (rigid rotator and non-rigid rotator model) Vibrational Spectra (harmonic and enharmonic model) Molecular Symmetric Top, Vibrating rotator Isotopic shift | 9 |
| **V** | Raman Spectra (Quantum mechanical and classical approach) Electronic Spectra-vibrational structure of band system, fine structure of the band systems. Intensity distribution in band systems | 9 |

**Suggested Readings**

1. Fundamentals of Molecular Spectroscopy, Third Edition, C.N. Banwell & E. M. McCash, McGraw-Hill book company, London, 1972.
2. Molecular Physics, W. Demtroder, Wiley-VCH Verlag GmbH & Co., KGaA, Weinheim, 2005.
3. Atomic and Molecular Spectra, Rajkumar, KNRN Publishing House, Meerut.
4. Atomic Physics, C. J. Foot (OUP Oxford)
5. Introduction to Atomic Spectra, H.E. White.

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx
4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/
5. edX, https://www.edx.org/course/subject/physics

**Course Prerequisites**

Physics as a major subject in B. Sc.

| Programme: **M. Sc.** | Year: I | Semester: VIII |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B010805P** | Course Title: **Electronics Lab** | |
| **Course Outcomes (COs)** | | |

1. The students learn to design and study the amplifiers in CB, CE and CC configurations.
2. The students gain knowledge on the variation of characteristics and constants of BJT, its Bias-stabilization and Band gap of semiconductor diodes.
3. The students are able to perform amplitude modulation and demodulation.
4. The students gain skills to design the Phase-Shift Oscillator, Tuned Collector Oscillator and Astable multivibrator.
5. The students learn the concept of Negative feedback.

| Credit: **4** | Core Compulsory |
|---|---|
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 0-0-8-0

**List of Experiments**

1. Band Gap of Ge and Si Diode
2. Negative Feedback
3. Modulation and Demodulation
4. Astable Multivibrator
5. 555 Timer IC
6. Field Effect Transistor (FET)
7. Silicon Controlled Rectifier (SCR)
8. Uni Junction Transistor (UJT)
9. Phase Shift Oscillator (PSO)
10. Hartley Oscillator
11. Tuned Collector Oscillator (TSO)
12. Design and Study of CE Amplifier

**Suggested Readings**

1. The Feynman Lectures on Physics, Vol. II: The New Millennium Edition: Mainly Electromagnetism and Matte, Richard P. Feynman, Robert B. Leighton, Matthew Sands (Pearson Education India, 2012)
2. Optics, Ajoy Ghatak (McGraw Hill, 2020)
3. Fundamentals of Optics, Francis Jenkins, Harvey White (McGraw Hill Education, 2017)

**Course Prerequisites**

Physics as a major subject in B. Sc.

| Programme: **M. Sc.** | Year: I | Semester: VIII |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B010806P** | Course Title: **General Lab** | |
| **Course Outcomes (COs)** | | |

In this course the experiments are designed to give understanding of heat, magnetism, electricity and optics experiments.

1. By determining the velocity of ultrasonic waves in a liquid at different temperatures using Ultrasonic interferometer, students build understanding of Ultrasonics as a non-destructive testing tool for measuring mechanical and elastic properties of solid and liquid materials.
2. Optical Properties of Quartz experiment helps the students not only in understanding the behaviour of light passing through different axes of crystal but also in understanding birefringence and chirality of quartz crystal.
3. Determination of Stefan's constant by electrical method helps students to clarify the concept of black body radiation.
4. Fabry-Perot Interferometer and Edser-Butler fringes experiments make students aware of different optical interference techniques being used in the field of Physics.
5. Fresnel's Formula and Study of Total Internal Reflection experiments help the students to understand the refraction and reflection phenomena.
6. By Curie Temperature experiment and Quincke's tube method experiment, students learn about magnetic properties of materials.
7. Iodine Absorption spectra experiment helps students learn about absorption spectra and associated parameters and properties of Iodine and thus other materials.

| | |
|---|---|
| Credit: **4** | Core Compulsory |
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 0-0-8-0

**List of Experiments**

1. Concave Grating, Hg Source Arc
2. Optical Properties of Quartz
3. Cornu's fringes
4. Fabry-Perot Interferometer
5. Edser-Butler Fringes
6. Fresnel's Formula
7. Study of Total Internal Reflection
8. Curie Temperature
9. Quincke's Tube method
10. Iodine Absorption Spectra
11. Stefan's Constant
12. Ultrasonic Interferometer – Variation of velocity with temperature
13. Forbidden Energy Gap of semiconductors
14. Laser Intensity diffraction pattern of different objects
15. Fourier Analysis

**Suggested Readings**

1. The Feynman Lectures on Physics, Vol. II: The New Millennium Edition: Mainly Electromagnetism and Matte, Richard P. Feynman, Robert B. Leighton, Matthew Sands (Pearson Education India, 2012)
2. Optics, Ajoy Ghatak (McGraw Hill, 2020)
3. Fundamentals of Optics, Francis Jenkins, Harvey White (McGraw Hill Education, 2017)
4. Introduction to Modern Optics, Grant R. Fowles (Dover Publications Inc, 1990)

| Course Prerequisites |
|---|
| Physics as a major subject in B. Sc. |

<table>
<tr><td colspan="2">Programme: M. Sc.</td><td>Year: I</td><td>Semester: VIII</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td colspan="2">Course Code: B010807R</td><td colspan="2">Course Title: Dissertation Phase 2</td></tr>
<tr><td colspan="4">Course Outcomes (COs)<br>After the completion of the course, students will (/be/able to)</td></tr>
<tr><td colspan="4">Learn to obtain relevant data through experiments/surveys/data repositories.</td></tr>
<tr><td colspan="2">Credit: 4</td><td colspan="2">Core Compulsory</td></tr>
<tr><td colspan="2">Max. Marks: 100</td><td colspan="2">Min. Passing Marks:</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 0-0-0-8</td></tr>
<tr><td></td><td colspan="3">Topics</td></tr>
<tr><td></td><td colspan="3">Data Collection on the Problem</td></tr>
<tr><td colspan="4">Suggested Readings</td></tr>
<tr><td colspan="4">1. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, J. W. Creswell (SAGE Publications, 2014)<br>2. The Craft of Research, Wayne C. Booth, Gregory Colomb, Joseph M. Williams, William Fitzgerald (University of Chicago Press, 2008)<br>3. As per the field of the project.</td></tr>
<tr><td colspan="4">Suggested Digital Platforms/Web Links</td></tr>
<tr><td colspan="4">1. Google Scholar (https://scholar.google.com/)<br>2. ScienceDirect (https://www.sciencedirect.com/)<br>3. Scopus (https://www.elsevier.com/en-in/solutions/scopus)<br>4. Web of Science (http://webofscience.com/wos/woscc/basic-search)</td></tr>
<tr><td colspan="4">Course Prerequisites</td></tr>
<tr><td colspan="4">Physics as a major subject in B. Sc.</td></tr>
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<table>
<tr><td colspan="2">Programme: M. Sc.</td><td>Year: I</td><td>Semester: VIII</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td colspan="2">Course Code: B010808M</td><td colspan="2">Course Title: Frontiers in Physics</td></tr>
<tr><td colspan="4">Course Outcomes (COs)<br>After the completion of the course, students will (/be/able to)</td></tr>
<tr><td colspan="4">1. To appreciate the emerging fields of research in Physics.<br>2. To address the vital topic of climate change and role of Physics in it.<br>3. To gain knowledge on applications of Physics in building sustainable future.<br>4. To develop a scientific temper and to contribute significantly in saving the environment.</td></tr>
<tr><td colspan="2">Credit: 4</td><td colspan="2">Minor Elective</td></tr>
<tr><td colspan="2">Max. Marks: 25+75</td><td colspan="2">Min. Passing Marks:</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0</td></tr>
<tr><td>Unit</td><td colspan="2">Topics</td><td>No. of Lectures</td></tr>
<tr><td>I</td><td colspan="2">Space and Time, Einstein's Special and General Relativity, Unified reality, Does time flow? Strings and all that, The elegant universe, Black holes, neutrinos, gravitational waves, dark matter.</td><td>9</td></tr>
<tr><td>II</td><td colspan="2">Basics of Nanotechnology, Application in medicine, Nano-therapy for combating cancer, what is green nanotechnology? Multi-dimensional impact of nanotechnology on health, nanotechnology in warfare, nano art, nano electronics, nano bots.</td><td>9</td></tr>
<tr><td>III</td><td colspan="2">The quantum world, Basic idea of probability, concept of continuous and discrete, quantum healing, quantum computation, quantum biology, QUBITS the new buzzword.</td><td>9</td></tr>
<tr><td>IV</td><td colspan="2">The Physics of climate change, structure of the atmosphere, composition of the earth's atmosphere, the ozone problem, greenhouse gases, carbon footprints and how to minimize them, factors controlling climate.</td><td>9</td></tr>
<tr><td>V</td><td colspan="2">Sustainable development and clean energy, renewable energy sources: solar cells, wind and hydropower; nuclear fusion.</td><td>9</td></tr>
<tr><td colspan="4">Suggested Readings</td></tr>
<tr><td colspan="4">1. Understanding the Universe: From Quarks to the Cosmos, Donald Lincoln (World Scientific Publishing Co Pte. Ltd., 2012)<br>2. Ripples in Spacetime – Einstein, Gravitational Waves, and the Future of Astronomy, Govert Schilling, Martin Rees (Harvard University Press, 2017)<br>3. Nanoscience: The Science of the Small in Physics, Engineering, Chemistry, Biology and Medicine, Hans-Eckhardt Schaefer (Springer, 2010)<br>4. The Quantum World: Quantum Physics for Everyone, Kenneth W. Ford (Harvard University Press, 2004)<br>5. Physics and Technology of Sustainable Energy, E. L. Wolf (Oxford University Press, 2018)</td></tr>
<tr><td colspan="4">Suggested Digital Platforms/Web Links</td></tr>
<tr><td colspan="4">1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics<br>2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html</td></tr>
</table>

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| 3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx<br>4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/<br>5. edX, https://www.edx.org/course/subject/physics |
| **Course Prerequisites** |
| Open to all. |

| Programme: **M. Sc.** | Year: II | Semester: IX |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B010901T** | Course Title: **Solid State Physics** | |

**Course Outcomes (COs)**

After the completion of the course, students will be/able to

1. Appreciate the need of band theory and figure out different types of band theory. Theory of semiconductors and fermi surface.
2. Grasp the concepts and basic ideas related to superconductivity and describe the
3. basic properties of Type I and Type II superconductors
4. Study of the ionic crystals in presence of infrared radiation. Conducting polymers.
5. Different type of lattice defects in solids and its application to generate colour centres, compute the number of vacancies in solids.
6. Explain the significance of different interactions and energies involved that explain the phenomena and properties of different types of magnetic materials. Classical and quantum theory of magnetic materials and its applications.

| Credit: **4** | Core Compulsory |
|---|---|
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Electron band theory: one electron band theories. Plane wave like and localized wave functions. Nearly free electron approximation. Elementary discussion of orthogonalized Plane Wave (OPW) and Pseudo potential methods, Variation of Fermi energy in extrinsic semiconductors, de-Hass-van Alphen effect experiment to investigate Fermi surface. | 9 |
| **II** | Superconductivity: Meissner effect, isotope effect, type I and II superconductors. Cooper pairs. Elementary ideas of BCS theory, Approximate estimate of transition temperature, superconducting energy gap, Measurement of energy gap by infrared absorption and electron tunnelling methods, Elementary ideas about Josephson effect and high Tc superconductors. | 9 |
| **III** | Ionic lattice in presence of infrared field, dielectric constant, L.S.T. relation, LO and TO modes, ordered phases of matter, translational and orientational order, Quasicrystals, conducting polymers. | 9 |
| **IV** | Lattice defects: Frenkel and Schottky defects, colour centres, number of defects (vacancies) in equilibrium, Dislocations, edge and screw Burgers vector. | 9 |
| **V** | Diamagnetism, Langevin diamagnetic equation, Quantum theory of para magnetism rare earth ions and iron group ions. Ferromagnetism, Curie temperature, Heisenberg model, Temperature dependence of saturated magnetization. | 9 |

**Suggested Readings**

1. Introduction to Solid State Physics C. Kittel, 8th Edition, John Wiley & Sons, Inc. New Jersey, USA (2012).

2. Solid State Physics, A. J. Dekker, McMillan India, (2000)
3. Solid State Physics, Neil. W. Ashocroft & N. David Mermin, Holt, Rinehart and Winston, (1976).
4. The Oxford Solid State Basics, Steven H. Simon 1st Edition, Oxford University Press, Oxford, UK, (2013).

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx
4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/
5. edX, https://www.edx.org/course/subject/physics

**Course Prerequisites**

Physics in M. Sc. I Year.

| | | |
|---|---|---|
| Programme: **M. Sc.** | Year: II | Semester: IX |
| Subject: **Physics** | | |
| Course Code: **B010902T** | Course Title: **Nuclear and Particle Physics** | |

**Course Outcomes (COs)**

After the completion of the course, students will be/able to

1. have understanding of n-n, n-p and p-p scattering and charge symmetry of nuclear forces.
2. explain reasons behind ground state properties of nucleus such as spin-parity assignment, angular moment and magnetic moment with the help of shell model.
3. analyze kinematics formulation associated with different nuclear reactions including relativistic heavy ion reactions.
4. predict if an elementary particle reaction is allowed and to recognize the type of the interaction associated with it.
5. have fundamental understanding of nuclear decays and associated selection rules.

| | |
|---|---|
| Credit: **4** | Core Compulsory |
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Deuteron, n-n scattering, n-p scattering, p-p scattering, charge symmetry of nuclear forces. | 9 |
| **II** | Shell Model, Extreme Single particle picture and angular momentum, magnetic moment, quadrupole moment of nuclei, Nuclear Isomerism, Collective model (qualitative discussion) | 9 |
| **III** | Compound Nucleus, Breit-Wigner Formula, Direct Interaction, Heavy | 9 |

| | | |
|---|---|---|
| | Ion Reactions, Relativistic Kinematics | |
| **IV** | Fundamental types of Interactions, General Classifications of Elementary Particles, Isospin, Strangeness, Conservation Laws, Symmetries (C, CP, CPT), SU(3) and quark model | 9 |
| **V** | Alpha, beta and gamma decay | 9 |
| **Suggested Readings** | | |
| 1. Introductory Nuclear Physics, Kenneth S. Krane<br>2. Nuclear Physics, V Devnathan<br>3. Introductory Nuclear Physics, Samual Wong<br>4. Introduction to Elementary Particle Physics, David J Griffiths (2008) | | |
| **Suggested Digital Platforms/Web Links** | | |
| 1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics<br>2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html<br>3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx<br>4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/<br>5. edX, https://www.edx.org/course/subject/physics | | |
| **Course Prerequisites** | | |
| Physics in M. Sc. I Year. | | |

| | | |
|---|---|---|
| Programme: **M. Sc.** | Year: II | Semester: IX |
| Subject: **Physics** | | |
| Course Code: **B010903T** | Course Title: **Analog and Digital Electronics** | |
| **Course Outcomes (COs)**<br>After the completion of the course, students will (/be/able to) | | |
| 1. have descriptive knowledge of op-amp. Study the Ideal Characteristic of op-amp and its AC and DC characteristics.<br>2. be able to perform different applications of op-amp in linear analog system.<br>3. be able to perform different applications of op-amp in non-linear analog system.<br>4. learn about principle and applications of different type of flip-flop, registers and counters.<br>5. learn about the frequency response of wide band amplifiers and role of different components in it. | | |
| Credit: **4** | Specialization I | |
| Max. Marks: 25+75 | Min. Passing Marks: | |
| Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0 | | |
| Unit | Topics | **No. of Lectures** |
| **I** | Operational Amplifier: Ideal op-amp, CMRR, Slew Rate, Offset error voltage and current and there balancing circuits. Temperature drifts, measurement of op-amp parameters. | 9 |

| | | |
|---|---|---|
| **II** | Op-amp Applications: Inverter, Scale changer, adder, voltage to current converter, current to voltage converter, voltage follower, Analog integration and differentiation, solution of simultaneous and differential equations, Active Butterworth filter. | 9 |
| **III** | Non-linear Analog System: Sample and hold circuits, Comparators, Zero-crossing Detector, Schmitt Trigger (regenerative comparator), log and antilog amplifiers, Clippers and Clampers. | 9 |
| **IV** | Digital Electronics: Flip Flop; SR, JK, Master-slave, Registers and counters; Shift Register, ripple counter, up down asynchronous and synchronous counters, ring counter. | 9 |
| **V** | Wide band amplifier: Review of BJT at high frequencies. Hybrid pi equivalent model, Junction capacitance. Effect of an emitter bypass capacitor on low frequency response. High and low frequency compensations. | 9 |

**Suggested Readings**

1. Integrated Electronics: Analog and Digital Circuits and system by J. Milliman and C. C. Halkias
2. Pulse, Digital and switching waveform by J. Milliman and H. Taub
3. Op-Amps and Linear Integrated Circuits by R. A. Gayakwad
4. Linear Integrated Circuits by D. R. Choudhury and S. B. Jain

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx
4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/
5. edX, https://www.edx.org/course/subject/physics

**Course Prerequisites**

Physics in M.Sc. 1st year

| Programme: **M. Sc.** | Year: II | Semester: IX |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B010904T** | Course Title: **Microwaves** | |

**Course Outcomes (COs)**

After the completion of the course, students will (/be/able to)

1. learn about different types of waveguides and their respective modes of propagation.
2. understand working of microwave passive circuits such as isolator, circulator, directional couplers, attenuators etc.
3. understand working of microwave tubes and solid-state devices.
4. be able perform measurements on microwave devices and networks using power meter.

| Credit: **4** | Specialization I |
|---|---|

| Max. Marks: 25+75 | | Min. Passing Marks: |
|---|---|---|
| Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0 | | |
| Unit | Topics | **No. of Lectures** |
| **I** | Introduction of microwaves, transmission line analysis, impedance matching, Smith chart, Waveguides (WG): wave equation, rectangular and circular WG, and cavity resonator. | 9 |
| **II** | Passive microwave devices: Scattering Matrix, Microwave Hybrid Circuits, Terminations, Attenuators, Phase Shifters, Directional Couplers, Isolators, Circulators, S-parameter analysis of all components. | 9 |
| **III** | Vacuum Tube Microwave Generators: Velocity modulation and density modulation, small signal theory of bunching, two cavity klystron amplifier, and Oscillator, Reflex klystron: Theory of bunching, optimum power, effect of repeller voltage, electronic admittance, efficiency, electronic tuning. | 9 |
| **IV** | Magnetron: Travelling wave magnetron, modes of oscillations, output power, travelling wave tube: Description, dynamic of electron beam, coupling of beam and slow wave structure. | 9 |
| **V** | Detection of microwaves, measurement of microwaves, measurement of VSWR, frequency, wavelength, microwave power, dielectric properties of materials, Applications of microwaves in material processing. | 9 |

**Suggested Readings**

1. H. A. Atwater, Introduction to Microwave Theory, McGraw Hill Publishing Co. (1962)
2. Samuel Y. Liao, "Microwave Devices and Circuits", 3rd Ed, Pearson Education.
3. D. C. Dube, "Microwave Devices and Applications", Narosa Publishing House, New Delhi, 2011
4. R.E Collins, "Foundation for Microwave Engineering ", 2nd Ed., John Wiley India.

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx
4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/
5. edX, https://www.edx.org/course/subject/physics

**Course Prerequisites**

Physics in M.Sc. 1$^{st}$ year

| Programme: **M. Sc.** | Year: II | Semester: IX |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B010905T** | Course Title: **Laser Spectroscopy** | |
| **Course Outcomes (COs)** | | |
| After the completion of the course, students will (/be/able to) | | |

1. have knowledge of various Light Sources (Arc, Spark, Discharge, Beam Foil etc.), Thermal and Direct Photo Detectors, Optical Multichannel Analyzer
2. understand the basic laser fundamentals, unique properties of the laser, fixed frequency and tuneable lasers, high and low power lasers.
3. learn principle and working of various lasers including gas, liquid and solid-state.
4. know principle and working of semiconductor lasers and its type, p-n junction laser.
5. learn about laser photoacoustic spectroscopy, laser induced fluorescence, Laser Raman Spectroscopy, Laser isotope separation, medical application of lasers

| | |
|---|---|
| Credit: **4** | Specialization II |
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Light Sources (Arc, Spark, Discharge, Beam Foil etc.), Synchrotron, Laser, Thermal and Direct Photo Detectors, Optical Multichannel Analyzer, Charged Coupled Devices (CCD), Integrated Charged Coupled Devices (ICCD). | 9 |
| **II** | Fixed-frequency and Tuneable lasers, YAG, Argon Ion, Excimer, Dye, Semiconductor Lasers | 9 |
| **III** | Laser Photoacoustic Spectroscopy, Laser Induced Fluorescence (LIF), Laser Optogalvanic Spectroscopy | 9 |
| **IV** | Laser Raman Spectroscopy (CARS, SRS, SERS), Time Resolved Spectroscopy | 9 |
| **V** | Fourier Transform Spectroscopy, Laser Isotope Separation, Medical Applications of Laser. | 9 |

**Suggested Readings**

1. Laser Spectroscopy and Instrumentation, Wolfgang Demtroder, Springer
2. Principles of Lasers, Svelto, Orazio, Fifth edition, Springer
3. Atom, Laser and Spectroscopy, 2nd Edition, Kindle Edition, S. N. Thakur, D. K. Rai
4. Laser and nonlinear optics, B.B. Laud, New Age International Pvt Ltd Publishers.
5. Lasers: Fundamentals and Applications, Thyagarajan, K., Ghatak, Ajoy, Springer
6. Principles of fluorescence spectroscopy by Joseph R. Lakowicz

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx
4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/
5. edX, https://www.edx.org/course/subject/physics

**Course Prerequisites**

Physics in M.Sc. 1st year

| Programme: **M. Sc.** | Year: II | Semester: IX |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B010906T** | Course Title: **Electronic Spectra of Diatomic Molecules** | |

**Course Outcomes (COs)**

After the completion of the course, students will (/be/able to)

1. be able to apply knowledge to detailed understanding of electronic spectra of diatomic molecule.
2. understand the classification of molecular states.
3. understand the continuous and diffuse spectra of diatomic molecule.

| Credit: **4** | Core Compulsory |
|---|---|
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Review of electronic spectra of diatomic molecules, Deslander's table, Franck Condon Principle | 9 |
| **II** | Symmetry properties of rotational levels for di-atomic molecule, Intensity of molecular band in electronic spectra. Nuclear spin and Intensity alternation in electronic band structure. | 9 |
| **III** | Classification of Molecular States, Multiplet Structure, Coupling and Uncoupling phenomena, Selection Rules for Electronic Transitions, | 9 |
| **IV** | Building up Principles. Electronic Configuration in diatomic molecule, Molecular Orbital Theory. | 9 |
| **V** | Continuous and diffused spectra, Pre-dissociation, Determination of dissociation energy of $O_2$, $I_2$ and $N_2$ molecules | 9 |

**Suggested Readings**

1. Gerhard Herzberg, Atomic spectra and atomic structure
2. Gerhard Herzberg, Molecular Spectra and Molecular Structure IV. Constants of Diatomic Molecules
3. G. Aruldhas, Molecular Structure and Spectroscopy.
4. C.N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy.
5. W. Demtroder, Molecular Physics.
6. Sune Svanberg, Atomic and Molecular Spectroscopy.

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx
4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/
5. edX, https://www.edx.org/course/subject/physics

**Course Prerequisites**

Physics in M.Sc. $1^{st}$ year

| Programme: **M. Sc.** | Year: **II** | Semester: IX |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B010907T** | Course Title: **Condensed Matter Physics-I** | |

**Course Outcomes (COs)**

1. Calculate the potential energy of solids by Ewald methods and Lorentz field.
2. Study of ab-intio theory of lattice dynamics for non-primitive lattice and theory of normal coordinates.
3. Understand distribution functions of quantum ideal gases and to study the low temperature thermodynamic behaviour of quantum ideal gases, theory of liquid helium and superfluid.
4. Quantization of lattice vibrations and optical properties of solids such as real and imaginary part of dielectric function.
5. Understanding of many body theory, basics of density functional theory and different type of exchange correlation functions such as LDA, GGA. Its application for calculation of electronic and optical properties of materials.
6. Different type of Martials and its characterization technique such as XRD, SEM, TEM, FTIR etc.

| Credit: **4** | Specialization III |
|---|---|
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Phonon concept, Quantization of lattice vibrations, Phonons in perfect-crystals: General theory of lattice dynamics of nonprimitive lattice, normal coordinate description, shell model. | 7 |
| **II** | Basic concept of optical constants, Kramer Kroning relation, optical properties of metals, polaritons, plasmons. Optical properties of semiconductors and heterostructures, excitons. Inter and intra band transition | 9 |
| **III** | Many body Techniques: The basic Hamiltonian in solid: Electronic and Ionic parts, Hartree and Hartree Fock equation, exchange energy, Density Functional Theory, Thomas Fermi approximation, Local Density Approximation (LDA), Generalized gradient approximation (GGA). | 10 |
| **IV** | Transport properties: Quantum Hall Effect: Integral and fractional hall effect, Landau quantization, Quantum spin hall effect, Topological Insulators. | 10 |
| **V** | 2D materials: Graphene and Transition metal di-chalcogenides (TMDs). Thermoelectric materials.<br>Characterization techniques: X ray diffraction (XRD), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), UV-Vis. | 9 |

**Suggested Readings**

1. Quantum Theory of Solids, C. Kittel, 2nd Ed., John Wiley and Sons, USA, 1987.
2. Density Functional Theory, David S. Sholl, Janice A. Steckel, Wiley & Sons (2009).
3. Electronic Structure Calculations for Solids and Molecules, J. Kohanoff, Cambridge University Press.

4. Computational Materials Science: An Introduction, June Gunn Lee, Second Edition, CRC press (2017).
5. Handbook of material Characterization, Surender K. Sharma, Springer (2018).
6. Materials Characterization: Introduction to microscopic and Spectroscopic Methods, Yang Leng, John Wiley & Sons (Asia) Pte Ltd (2008).

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx
4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/
5. edX, https://www.edx.org/course/subject/physics

**Course Prerequisites**

Physics in M.Sc. 1st year

| Programme: **M. Sc.** | Year: **II** | Semester: **IX** |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B010908T** | Course Title: **Condensed Matter Physics-II** | |

**Course Outcomes (COs)**

1. Understand the dielectric and optical properties of ionic crystals.
2. Understand the basic concepts behind the different Raman scattering.
3. Learn the concept of Phonon, correlation functions and principle of causality.
4. Understand the role of defects in tailoring the optical and electrical properties of solids.
5. Execute the application of Green's function to explore the properties of solids.

| Credit: **4** | Specialization III |
|---|---|
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Dielectric constant of ionic crystals. Static polarizability, polarizability in variable field, Placzek's approximation, first order Raman scattering, second-order Raman scattering, | **9** |
| **II** | Elementary ideas of the study of phonons by Raman scattering Plasmons, interaction of electromagnetic waves with phonons and polaritons. | **9** |
| **III** | Excitation in imperfect crystals: Definition of classical Green functions, application to one dimensional harmonic oscillator, principle of causality. Double-time quantum Green functions, correlation functions, spectral density. | **9** |

| | | |
|---|---|---|
| **IV** | Static Green function (Fourier transform), application to lattice vibrations and electron energy states. | **9** |
| **V** | Point defect in one-dimensional lattice, localized, gap and resonance modes. Elementary ideas of extension to impurity electron energy states, gap states. | **9** |
| **Suggested Readings** | | |
| **1.** Introduction to Solid State Physics: C. Kittel<br>**2.** The Green Function in Solid State Physics, J. Mahanti.<br>**3.** Dynamical Theory of Crystal Lattice, Max Born and Kun Huang<br>**4.** Quantum Theory of Solids, J. Callaway<br>**5.** Elementary Solid-State Physics, Omar, M.A., Pearson Education, (1999). | | |
| **Suggested Digital Platforms/Web Links** | | |
| 1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics<br>2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html<br>3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx<br>4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/<br>**5.** edX, https://www.edx.org/course/subject/physics | | |
| **Course Prerequisites** | | |
| Physics in M.Sc. 1st year | | |

| | | |
|---|---|---|
| Programme: **M. Sc.** | Year: II | Semester: IX |
| Subject: **Physics** | | |
| Course Code: **B010912R** | Course Title: **Dissertation Phase 3** | |
| **Course Outcomes (COs)**<br>After the completion of the course, students will (/be/able to) | | |
| to analysis the relevant data. | | |
| Credit: **4** | Core Compulsory/Elective | |
| Max. Marks: 100 | Min. Passing Marks: | |
| Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 0-0-0-8 | | |
| | Topics | |
| | **Data Analysis** | |
| **Suggested Readings** | | |
| 1. As per the field of the project. | | |
| **Suggested Digital Platforms/Web Links** | | |
| 1. Google Scholar (https://scholar.google.com/)<br>2. ScienceDirect (https://www.sciencedirect.com/)<br>3. Scopus (https://www.elsevier.com/en-in/solutions/scopus)<br>4. Web of Science (http://webofscience.com/wos/woscc/basic-search) | | |
| **Course Prerequisites** | | |
| Physics as a major subject in B. Sc. | | |
| **Suggested Continuous Internal Evaluation (CIE) Methods** | | |
| | | |
| **Suggested Equivalent Online Courses (if any)** | | |

| Programme: **M. Sc.** | Year: II | Semester: X |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B011001T** | Course Title: **Experimental Techniques & Control Systems** | |

**Course Outcomes (COs)**

After the completion of the course, students will (/be/able to)

1. able to analyse different experimental techniques used in laboratories.
2. learn principle and working of some optoelectronic and thermoelectric devices.
3. understand the characteristics and applications of an operational amplifier.
4. have ability to analyse different circuits and its methodology used for conversion of analog to digital or digital to analog data.
5. learn the basic concepts of microprocessor with some set of instructions used.

| Credit: **4** | Core Compulsory |
|---|---|
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Data Interpretation and Analysis: precision and accuracy, error analysis, propagation of errors, least squares fitting, linear and non-linear curve fitting, chi-square test. | 9 |
| **II** | Thermoelectric properties of materials, Thermoelectric generator, Optoelectronic Devices; solar cells, photo-detector, transducers | 9 |
| **III** | Ideal operational amplifier, characteristics and applications; Inverting and non-inverting amplifier, integrator, differentiator, adder and comparator. | 9 |
| **IV** | Analogue v/s digital data: Statement of sampling theorem, A/D converters Flash converters, single slope, double slope and successive approximation converter), D/A converter (R-2R ladder type and weighted resistor type converter). | 9 |
| **V** | Fourier Transforms and lock-in detector, Box car averaging. Microprocessor 8085 and microcontroller basics, Instruction set related to Data transfer Group. Addressing I/0 devices (Memory mapped & I/0 mapped I/O) | 9 |

**Suggested Readings**

1. Pulse, Digital and switching waveform by J. Milliman and H. Taub
2. Op-Amps and Linear Integrated Circuits by R. A. Gayakwad
3. Electronics: Fundamental and Applications by D. Chattopadhyay and P. C. Rakshit
4. Microprocessor Architecture, programming and applications with 8085 by R. S. Gaonkar

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics

| |
|---|
| 2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html<br>3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx<br>4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/<br>5. edX, https://www.edx.org/course/subject/physics |
| **Course Prerequisites** |
| Physics in M.Sc. $1^{st}$ year |

| Programme: **M. Sc.** | Year: **II** | Semester: X |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B011002T** | Course Title: **Computational Physics with Python** | |

**Course Outcomes (COs)**

1. have fundamental understanding of different operating systems and working on Linux preferably Ubuntu.
2. have knowledge of different features of Python programming language including module, package and libraries.
3. can manage and manipulate data in different datafiles for desired calculations and draw 2D and 3D plots and graphs for data sets and functions.
4. be able to write computer programs for different numerical methods and perform numeric integration and differentiation.
5. can generate random numbers and solve waves equations including Schrödinger 's equation using programming.

| Credit: **4** | Elective I |
|---|---|
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Introduction to Operating systems, Linux, Python Basics: Interpreter, statements, variables, mathematical operators, loops, functions, libraries and modules, class and object, and simple applications. | 11 |
| **II** | Python libraries: NumPy, SciPy, matplotlib, pandas; extracting data from datafiles, managing datasets. 2D and 3D plots and graphs | 10 |
| **III** | Programming for Newton-Raphson method, iterative method, Newton's forward and backward interpolation. | 7 |
| **IV** | Numeric integration and differentiation, Euler's methods, Runge-Kutta methods for ODE, matrix manipulation | 7 |
| **V** | Programming for the motion of real pendulum, Random numbers, Monte-Carlo method, the random walk, Ising model and solution of wave equations, Schrödinger 's equation. | 10 |

**Suggested Readings**

1. Computational Physics with Python, Eric Ayars (California State University, 2013).
2. Computational Physics: Problem Solving with Python, 3rd edition, Rubin H. Landau, Manuel J. Paez, (Wiley-VCH, 2015).
3. Introducing Python: Modern Computing in Simple Packages, B. Lubanovic, (O'Reilly Media, Inc, 2015).
4. A Primer on Scientific Programming with Python, Hans Petter Langtangen (2014)

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx

| |
|---|
| 4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/ <br> 5. edX, https://www.edx.org/course/subject/physics |
| **Course Prerequisites** |
| Physics in M. Sc. Physics I Year |

| Programme: **M. Sc.** | Year: **II** | Semester: **X** |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B011003T** | Course Title: **Advanced Electrodynamics and Second Quantization** | |
| **Course Outcomes (COs)** | | |
| 1. Solution of inhomogeneous equation by Green's function method. Advance and retarded green function. Analyse the Lienard-Wiechert Potential, calculate fields and power radiation due to moving charges. <br> 2. Analysis and calculate the radiation from an accelerating charge and oscillating dipole. Calculation of electric and magnetic field of oscillating dipole. <br> 3. Study of radiation force, radiation reaction and line width of an oscillator. <br> 4. Covariant formulation of Lagrangian and its tensor form for energy, momentum and current density in four vector form. <br> 5. Understanding of second quantization and its application in electromagnetic field. Problems on boson and fermion Creation and Annihilation. | | |
| Credit: **4** | Elective II | |
| Max. Marks: 25+75 | Min. Passing Marks: | |
| Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0 | | |

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Radiation from a Moving Charge: Solution of Inhomogeneous Wave equation, Greens Functions, Lienard-Wiechert Potentials and Field from a moving charge, Larmor's formula and its Relativistic Generalization | 9 |
| **II** | Angular Distribution of Radiation from an Accelerated Charge, Electromagnetic Field and Radiation from an Oscillating Localized Source. | 9 |
| **III** | Radiation Reaction and Self-Force: Radiation Reaction Force from Conservation of Energy, Line Width and Level Shift of an Oscillator. | 9 |
| **IV** | Covariant Lagrangian Formalism, Noether's Theorem, Energy Momentum, Angular Momentum and Spin Tensors, Current Density Four Vector. | 9 |
| **V** | Second Quantization of Scalar field and of Electromagnetic Field in Radiation Gauge and of Dirac Field, Spin of Photons, Simple Problems on Algebra of Annihilation and Creation Operators. | 9 |

**Suggested Readings**

1. Classical Electrodynamics, J. D Jackson, Wiley India.
2. Introduction to Electrodynamics, D. J. Griffths, Pearson, (2014).

3. Introduction to the Principles of Electromagnetism, Walter Hauser, Addison-Wesley Educational Publishers Inc, (1971).
4. Classical Electromagnetic Radiation, M A Heald and J B Marion, Academic Press, NY (1980)
5. Classical Electromagnetic Theory, Jack Vanderlinde, Springer (2007).

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx
4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/
5. edX, https://www.edx.org/course/subject/physics

**Course Prerequisites**

Physics in M. Sc. I Year

| Programme: **M. Sc.** | Year: II | Semester: X |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B011004T** | Course Title: **Group Theory** | |

**Course Outcomes (COs)**

1. understand the classification of finite groups.
2. Have basic mathematical concepts for working with group theory and also apply the knowledge of matrices for solving linear algebraic equations.
3. Analyse theorems in group theory and apply matrix representation of group for solving physics problems.
4. Learn about the role played by symmetries in studying classical and Quantum theories.
5. Learn basics of group theory and prepare group character tables for understanding crystallography.

| Credit: **4** | Elective III |
|---|---|
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Group theory and its application: Abstract definitions: Group, Multiplication Table, Sub-groups, Isomorphism and homomorphism, complexes, Cosets and classes, Indirect-group, Direct product of groups. | 9 |
| **II** | Theory of Representation: Linear vector space, basis, matrix representation of operators, unitary space, Unitary matrices, representation of group, characters, reducible and irreducible representations, Invariant subspaces, Schur's Lemmas | 9 |
| **III** | Orthogonality theorem for irreducible representation and characters Regular representation, occurrence of, an irreducible representation in a reducible representation. | 9 |

| | | |
|---|---|---|
| **IV** | Theorem for possible number of irreducible representations of a group. Direct product of representations. Relationship to Quantum mechanics: Symmetry transformations, degeneracy and invariant subspaces, projection operators, transformation of functions. | 9 |
| **V** | Applications to molecular and crystal symmetry, Fundamental point group operations and nomenclature, construction of thirty-two-point groups and character tables for their irreducible representations. | 9 |

**Suggested Readings**

1. Elements of Group Theory for Physicists, A.W. Joshi (John Wiley, 1997).
2. Groups and Symmetry, M. A. Armstrong (Springer, 1988).
3. Advanced Method of Mathematical Physics, R. S. Kaushal & D. Parashar (Narosa, 2008).
4. Group Theory and Its Applications to Physical Problems, M. Hamermesh (Dover, 1989).
5. Mathematical Methods for Physicists, G. Arfken, H. Weber, & F. Harris (Elsevier, 2012).

**Suggested Digital Platforms/Web Links**

**Course Prerequisites**

Physics as a major subject in B. Sc.

| Programme: **M. Sc.** | Year: II | Semester: X |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B011005T** | Course Title: **Microprocessor** | |

**Course Outcomes (COs)**

After the completion of the course, students will (/be/able to)

1. gain introductory knowledge of microprocessor 8085 architecture and its operations.
2. learn different set of instructions and their addressing modes.
3. able to design and perform some programs based on 8085
4. able to explain the techniques of Interrupts in 8085 and basic idea of 8255.
5. learn about different interfacing techniques of memory and I/O devices and working of ADC 0809 and DAC 08 for data conversion.

| Credit: **4** | Specialization I |
|---|---|
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Microprocessor 8085: Hardware description, Programmable Registers, Generation of control signal, Instruction cycle and machine cycle. | 9 |
| **II** | Instruction set and addressing mode: Data transfer group, Arithmetic group, Branch group, Logic group, Stack operation, input/output and machine control group. | 9 |

| | | |
|---|---|---|
| **III** | Simple programs based on instruction set, Counters and time Delay, Stack and Subroutines. | 9 |
| **IV** | 8085 Interrupts, PIA 8255 Handshaking, via interrupt and polling. | 9 |
| **V** | IC ADC0809 and DAC08, Pin Out their interfacing with 8085, Memory organization and mapping, interfacing in I/O mapped and memory mapped I/O schemes. CMOS devices as RAM and ROM. | 9 |

**Suggested Readings**

1. Microprocessor Architecture, programming and applications with 8085 by R. S. Gaonkar
2. Microprocessor System the 8086 / 8088 Family by Liu and Gibson
3. Microprocessor and Interfacing by D. V. Hall
4. Fundamentals of Microprocessor by B. Ram

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx
4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/
5. edX, https://www.edx.org/course/subject/physics
6. Tutorialspoint https://www.tutorialspoint.com/microprocessor/microprocessor_8085_architecture.htm

**Course Prerequisites**

Physics in M.Sc. 1st year

| Programme: **M. Sc.** | Year: II | Semester: X |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B011006T** | Course Title: **Physics of Semiconductor Devices** | |

**Course Outcomes (COs)**

After the completion of the course, students will (/be/able to)

1. have knowledge of semiconductors
2. have knowledge of semiconductor carrier properties and statistics
3. have knowledge of semiconductor carrier action
4. have ability to apply standard device models to explain/calculate critical internal parameters and standard characteristics of the PN-junction diode
5. have ability to apply standard device models to explain/calculate critical internal parameters and standard characteristics of Varactor Diode, Tunnel Diode, Gunn Diode
6. have ability to apply standard device models to explain/calculate critical internal parameters and standard characteristics of the Microwave Bipolar Junction Transistor

| Credit: **4** | Specialization I |
|---|---|
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Semiconductor Physics: Carrier concentration in intrinsic and extrinsic semiconductors, recombination process, current density and continuity equations. | 9 |
| **II** | P-n junction diode: Junction and diffusion capacitance, Ideal diode equation, temperature dependence of voltage and current. | 9 |
| **III** | Varactor diode and parametric conversion and amplification, Tunnel diode, V-I characteristics, tunnel diode as an amplifier and as an oscillator. | 9 |
| **IV** | Gunn diode, modes of operation, power and frequency performance. Impact Diode: Static and dynamic characteristic, small signal analysis and negative conductance, power and frequency performance, Schottky effect and Schottky diode. | 9 |
| **V** | Microwave transistor, cut off frequency, device geometry and performance. | 9 |

**Suggested Readings**

1. S. M. Sze, Kwok K. Ng, Physics of Semiconductor Devices, Third Edition, Wiley Inter science
2. Donald A. Neamen, An Introduction to Semiconductor Devices, McGraw-Hill, 2006
3. Jasprit Singh, Semiconductor Devices, John Wiley Sons, New York, 2001
4. Michael Shur, Physics of Semiconductor Devices, Pearson India Education Services Pvt. Ltd., Noida, 2019
5. Peter Y. Yu and Manel Cardona, Fundamentals of Semiconductors, Physics and Materials Properties, Springer Heidelberg Dordrecht, London, 2010.
6. P. John Paul, Electronic Devices and Circuits, New Age International (P), Ltd., Publishers, New Delhi, 2017
7. Massimo Rudan, Physics of Semiconductor Devices, Springer New York Heidelberg Dordrecht, London, 2015

**Suggested Digital Platforms/Web Links**

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/courses/108108122
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx
4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/
5. edX, https://www.edx.org/course/subject/physics

**Course Prerequisites**

Physics in M.Sc. 1st year

<table>
<tr><td colspan="2">Programme: M. Sc.</td><td colspan="2">Year: II</td><td>Semester: X</td></tr>
<tr><td colspan="5">Subject: Physics</td></tr>
<tr><td colspan="2">Course Code: B011007T</td><td colspan="3">Course Title: Advanced Atomic Spectroscopy</td></tr>
<tr><td colspan="5">Course Outcomes (COs)</td></tr>
<tr><td colspan="5">1. Learn about Lamb-shift in hydrogen atom and properties of complex spectra and their interpretation<br>2. Derivation of spectral term using Breit's scheme, Rydberg atoms<br>3. Know the limitations of optical microscopes<br>4. Learn about various microscopy techniques (SEM, TEM, AFM etc)<br>5. Basic idea of fluorescence microscopy</td></tr>
<tr><td colspan="3">Credit: 4</td><td colspan="2">Specialization II</td></tr>
<tr><td colspan="3">Max. Marks: 25+75</td><td colspan="2">Min. Passing Marks:</td></tr>
<tr><td colspan="5">Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0</td></tr>
<tr><td>Unit</td><td colspan="3">Topics</td><td>No. of Lectures</td></tr>
<tr><td>I</td><td colspan="3">Lamb – shift in hydrogen spectrum.</td><td>9</td></tr>
<tr><td>II</td><td colspan="3">Complex Spectra and their interpretation, nitrogen, oxygen and manganese as examples, Alternation of multiplicities, Inversion of states.</td><td>9</td></tr>
<tr><td>III</td><td colspan="3">Breit's Scheme for spectral term derivation, Rydberg atoms and Rydberg states.</td><td>9</td></tr>
<tr><td>IV</td><td colspan="3">Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES), Inductively Coupled Plasma Mass Spectroscopy (ECP-MS) Photo electron spectroscopy (PES), Auger Electron Spectroscopy (AES), X-Ray Fluorescence Spectroscopy (XRF).</td><td>9</td></tr>
<tr><td>V</td><td colspan="3">Limitations of Optical Microscope and Electron Microscope, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Tunneling Electron Microscopy (STEM), Fluorescence Microscopy.</td><td>9</td></tr>
<tr><td colspan="5">Suggested Readings</td></tr>
<tr><td colspan="5">1. Atomic spectra & atomic structure, Gerhard Hertzberg: Dover publication, New York.<br>2. Introduction to Infrared and Raman spectroscopy, Norman D Colthup, Lawrence H Daly and Stephen E Wiberley, Academic press, NY.<br>3. Molecular Spectra and Molecular Structure, Volume. I: Spectra of diatomic molecules by Gerhard Herzberg<br>4. Molecular structure & spectroscopy, G. Aruldhas; Prentice – Hall of India, New Delhi.<br>5. Principles of fluorescence spectroscopy by Joseph R. Lakowicz.</td></tr>
<tr><td colspan="5">Suggested Digital Platforms/Web Links</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">Course Prerequisites</td></tr>
<tr><td colspan="5">Physics as a major subject in B. Sc.</td></tr>
</table>

| | | |
|---|---|---|
| Programme: **M. Sc.** | Year: **II** | Semester: **X** |
| Subject: **Physics** | | |
| Course Code: **B011008T** | Course Title: **IR & Raman Spectra of Polyatomic Molecules** | |

| **Course Outcomes (COs)** | | |
|---|---|---|
| 1. Able to describe group theory to classify the molecules and to recognize the symmetry of molecules.<br>2. Describe the detailed concept of Infrared and Raman spectra of Polyatomic molecules.<br>3. Understand selection rules to explain transitions.<br>4. Describe vibrational and rotational spectra of polyatomic molecule. | | |
| Credit: **4** | Specialization II | |
| Max. Marks: 25+75 | Min. Passing Marks: | |
| Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0 | | |

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Symmetry Elements and Symmetry Operations, Point Groups, Classification of Molecules into Point Groups. | 9 |
| **II** | Rotational vibration spectra of Linear molecule, Selection Rules and Transition of Rigid Rotator, Parallel and Perpendicular bands in linear molecules. | 9 |
| **III** | Vibrational Motion, Normal co-ordinates and Normal modes of vibration, Accidental degeneracy, Vibrational Energy, Symmetry Co-ordinates, Symmetries of Normal modes of Vibration of $N_2O$ and $CO_2$ molecules. | 9 |
| **IV** | Pure Rotational Structure in the Raman and Far Infrared Spectra of Linear molecules, Alternation of Intensity. Active and Inactive IR and Raman Fundamentals, Functional Group Analysis. | 9 |
| **V** | Interaction of Rotation and Vibration, Rotation Vibration Spectra of Linear Polyatomic Molecule, Energy levels and Symmetry Properties, Coriolis Interaction, IR and Raman Spectra of Linear Polyatomic Molecule. | 9 |

**Suggested Readings**

1. Herzberg, G, Infrared and Raman Spectra of Polyatomic Molecules.
2. G. Aruldhas, Molecular Structure and Spectroscopy.
3. C.N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy.
4. S. Chandra, Molecular Spectroscopy.
5. Sune Svanberg, Atomic and Molecular Spectroscopy.

**Suggested Digital Platforms/Web Links**

**Course Prerequisites**

Physics as a major subject in B. Sc.

| Programme: **M. Sc.** | Year: **II** | Semester: **X** |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B011009T** | Course Title: **Condensed Matter Physics- III** | |
| **Course Outcomes (COs)** | | |
| 1. Gain the knowledge about the transport properties of solids and its application.<br>2. Understand a more elaborate view on lattice dynamics leading to plotting a determining phonon dispersion curve. | | |

3. Understand the properties of semiconductors like thermal conductivity, specific heat capacities, electrical conductivity and their dependence temperature etc.
4. Understand the various types of magnetic phenomena like diamagnetism, para-magnetism, ferromagnetism, anti-ferromagnetism and ferrimagnetism exhibited by different solids.
5. Gain the knowledge about magnetic phase transitions, critical phenomena, Ising Model, ordered parameters and concept of magnons etc.

| | |
|---|---|
| Credit: **4** | Specializiation III |
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Transport Theory: Phenomenological coefficient $L_{ij}$ and their physical inter reaction. General Boltzmann equation and its linearization Entropy production. Relaxation time solution of Boltzmann equation. | 9 |
| **II** | Electronic contributions of thermal and electrical conductivities and to Peltier, Seeback coefficient for metals and electronic semiconductors. Relationship between electrical and ideas about lattice contribution to thermal conductivity. | 9 |
| **III** | Magnetism: Classical and Semi Classical Theories: Failure to explain large internal fields. Exchange interaction. Ising Model. Bragg William Approximation. Explanation of large external fields. Non-existence of ferromagnetism in two-dimensional Ising Model. Two sub-lattice Model and classical theories of anti-ferromagnetism and ferrimagnetism, Ferrites and garnets. | 9 |
| **IV** | Second Quantized Theory: Ferromagnetic Heisenberg Hamiltonian, Holstein-Primakoff transformations and their application to Heisenberg Hamiltonian for small fractional spin reversal. Ferromagnetic magnons, Magnon heat capacity and saturation magnetization at small temperatures. Antiferromagnetic Hamiltonian and its reduction using Holstein Primakoff transformation, Antiferromagnetic magnons. Zeropoint sub-lattice magnetization. | 9 |
| **V** | The Magnetic Phase Transition: Order parameter, Landau's theory of second order phase Transitions. Fluctuations of the order parameter. Elementary qualitative ideas about critical exponents and scaling. | 9 |

**Suggested Readings**

1. Introduction to Solid State Physics: C. Kittel
2. The Green Function in Solid State Physics, J. Mahanti.
3. Dynamical Theory of Crystal Lattice, Max Born and Kun Huang
4. Quantum Theory of Solids, J. Callaway
5. Elementary Solid State Physics, Omar, M.A., Pearson Education, (1999).
6. Solid State Physics, Ashcroft, N.W. and Mermin, N.D., Cengage Learning, (2008).
7. Solid State Physics: A. J. Dekker
8. Solid State Physics: M.A. Wahab

**Suggested Digital Platforms/Web Links**

**Course Prerequisites**

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|---|
| Physics as a major subject in B. Sc. |

| | | |
|---|---|---|
| Programme: **M. Sc.** | Year: **II** | Semester: **X** |
| Subject: **Physics** | | |
| Course Code: **B011010T** | Course Title: **Condensed Matter Physics- IV** | |
| **Course Outcomes (COs)** | | |
| 1. Basics of second quantization for fermions and its application for solving the Hamiltonian of Columbian interaction.<br>2. Generalized theory of dielectric function and its application for metals and plasma in high and low frequency limit.<br>3. Understanding of electron-phonon interaction and solving its Hamiltonian within external perturbation potentials.<br>4. Study of electron-electron interaction via phonon (BCS theory). Solution of second quantization form of interacting Hamiltonian by Bogoliubo- Valatin transformation.<br>5. Understanding of temperature dependent properties of superconductivity and flux quantization. | | |
| Credit: **4** | Specializiation III | |
| Max. Marks: 25+75 | Min. Passing Marks: | |
| Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 3-1-0-0 | | |

| Unit | Topics | **No. of Lectures** |
|---|---|---|
| **I** | Many Electron Systems: Second quantization for Fermions, field operators, electron density operator, Hamiltonian for two particle interactions in second quantized form: Coulombian interaction and screened Coulombian interaction. | 9 |
| **II** | Linear Response Theory: Dielectric response analysis, dielectric constant for electron gas in self-consistent approximation, Lindhard formula, dielectric constant. Dielectric screening of a point charge impurity. | 9 |
| **III** | Electron-Phonon Interaction: Long wavelength limit, deformation potential interaction, Born approximation, deformation potential perturbation Hamiltonian, Normal processes, polaron. Number of phonons accompanying electron. | 9 |
| **IV** | Electron-electron interaction via phonons, Attractive interaction, Cooper pairs, Reduced Hamiltonian for superconducting state. Bogoliubo-Valatin transformation, Diagonal and non-diagonal terms. | 9 |
| **V** | Superconducting ground state energy, nature of ground state, excited states, Temperature dependence of energy gap, Transition temperature, Simple treatment of Meissner effect and flux quantization. | 9 |

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| **Suggested Readings** |
| 1. Quantum Theory of Solids, C. Kittel, 2nd Ed., John Wiley and Sons, USA, 1987.<br>2. Quantum Theory of Solid State, Joseph Callaway, Academic Press (1991).<br>3. Principles of the Theory of Solids", J.M. Ziman |
| **Suggested Digital Platforms/Web Links** |
| |
| **Course Prerequisites** |

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|---|
| Physics as a major subject in B. Sc. |

| | | |
|---|---|---|
| Programme: **M. Sc.** | Year: II | Semester: IX/X |
| Subject: **Physics** | | |
| Course Code: **B010909P/B011011P** | Course Title: **Electronics Lab** | |
| **Course Outcomes (COs)** | | |
| **1.** The students can perform mode analysis of klystron and characterization of directional coupler and Magic T and calibration of Attenuator.<br>**2.** The students are able to measure VSWR and complex dielectric constants of materials at microwave frequency and to verify the square law of crystal detector.<br>**3.** The students can explain steady state and transient response of wide band amplifier.<br>**4.** The students learn about A/D and D/A converter and perform conversion from Analog to Digital signal (and vis-versa). | | |
| Credit: **4** | Specialization I | |
| Max. Marks: 25+75 | Min. Passing Marks: | |
| Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 0-0-8-0 | | |
| **List of Experiments** | | |
| **1.** Characterization of Op-Amp: bias current, offset current, offset voltage, inverting amplifier, non-inverting amplifier, CMRR, Slew rate, etc.<br>**2.** Application of Op-Amp: Integrator, Differentiator, Voltage follower, Differential Amplifier, etc.<br>**3.** Active Filters<br>**4.** Analog computation<br>**5.** A/D and D/A converter<br>**6.** Microprocessor 8085<br>**7.** IC Familiarization<br>**8.** Video Amplifier<br>**9.** Microstrip Line<br>**10.** GUNN Diode and Magic T<br>**11.** Mode analysis of Klystron and Directional Coupler<br>**12.** Dielectric constant | | |
| **Course Prerequisites** | | |
| Physics in M. Sc. I Year. | | |

| | | |
|---|---|---|
| Programme: **M. Sc.** | Year: II | Semester: IX |
| Subject: **Physics** | | |
| Course Code: **B010910P/B011012P** | Course Title: **Laser and Spectroscopy Lab** | |
| **Course Outcomes (COs)** | | |
| **1.** Study of Zeeman effect experiment enable students to determine the energy levels in atoms and identify them in terms of angular momenta.<br>**2.** The “Study of LIF spectra” and “Laser excited spectra” helps students learn about optical spectroscopic techniques where Laser induced fluorescence and excitation of the sample are used. | | |

3. The students learn to measure the intensity of spectral lines and detect unknown elements by recoding emission spectra.
4. The students gain skills to study properties associated with absorption, reflectance, transmission and basic fluorescence of different samples using the Fibre Optic UV-Vis Spectrometer.

| Credit: **4** | Specialization II |
|---|---|
| Max. Marks: 25+75 | Min. Passing Marks: |
| Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 0-0-8-0 | |

**List of Experiments**

1. Study of Zeeman Effect
2. Study of L.I.F spectra
3. Study of Laser excited spectra
4. Laser induced fluorescence study of chlorophyll.
5. Intensity measurement of spectral lines.
6. Detection of unknown elements by recording emission spectra.
7. LED and Laser Diode Characteristics
8. Fiber Optic UV-Vis Spectrometer for Absorbance of powder, liquid & thin film Samples.
9. Fiber Optic UV-Vis Spectrometer for Reflectance of powder, liquid & thin film Samples.
10. Fiber Optic UV-Vis Spectrometer for Transmission of powder, liquid & thin film Samples.

Fiber Optic UV-Vis Spectrometer for Basic Fluorescence of Liquid Samples

**Course Prerequisites**

Physics in M. Sc. I Year.

| Programme: **M. Sc.** | Year: II | Semester: IX/X |
|---|---|---|
| Subject: **Physics** | | |
| Course Code: **B010911P/B011013P** | Course Title: **Condensed Matter Physics Lab** | |

**Course Outcomes (COs)**

After the completion of the course, students will (/be/able to)

1. learn to measure the Lande-g factor of electron for standard ESR sample (DPPH) using portable ESR spectrometer.
2. can demonstrate the concept of X-Ray diffraction by different crystal structure and analyse the diffraction pattern of those crystal structures to determine the lattice parameter.
3. Hall effect experiment help the students in building the concept of transport properties in semiconductors, Hall coefficient and their dependence of temperature.
4. With the help of Four Probe method, the students gain the knowledge about the variation of resistivity of the Ge/Si sample with temperature and can determine the energy gap of the sample.
5. NMR spectrometer enable the students to understand the concept of Zeeman interaction of magnetic dipoles associated with the nucleus and thus, to measure

the Lande-g factor of different samples like Glycerine, Copper Sulphate and Iron Chloride etc.

6. Lattice Dynamics experiment helps the student to understand the concept of acoustical modes, optical modes, and energy gap etc. of mono-atomic and di-atomic lattices.

| | |
|---|---|
| Credit: **4** | Specialization III |
| Max. Marks: 25+75 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 0-0-8-0

**List of Experiments**

1. X-Ray Diffraction
2. Hall Effect
3. Measurement of Energy Gap in Semiconductor Four Probe Method.
4. Hysteresis Characterization of Different Samples.
5. Lattice Dynamics of monoatomic and diatomic lattices.
6. Measurement of Curie Temperature.
7. ESR Experiment.
8. Measurement of tunnelling current through a metal-insulator junction.
9. Thermoluminescence of F-centres.
10. Measurement of energy gap, refractive index, and absorption coefficient of semiconductor by using optical method.

**Course Prerequisites**

Physics in M. Sc. I Year.

| | | |
|---|---|---|
| Programme: **M. Sc.** | Year: II | Semester: X |
| Subject: **Physics** | | |
| Course Code: **B011014R** | Course Title: **Dissertation Phase 4** | |

**Course Outcomes (COs)**

After the completion of the course, students will (/be/able to)

1. To extract significant results from data.
2. Develop oral and written communication skills.
3. To work on research level projects which is suitable to communicate/present in workshops and conferences.

| | |
|---|---|
| Credit: **4** | Core Compulsory |
| Max. Marks: 100 | Min. Passing Marks: |

Total No. of Lectures-Tutorials-Practical-Research (in hours per week): L-T-P-R: 0-0-0-8

| | Topics | |
|---|---|---|
| | **Final Report Submission and Presentation** | |

**Suggested Readings**

As per the field of the project.

**Suggested Digital Platforms/Web Links**

1. Google Scholar (https://scholar.google.com/)
2. ScienceDirect (https://www.sciencedirect.com/)
3. Scopus (https://www.elsevier.com/en-in/solutions/scopus)
4. Web of Science (http://webofscience.com/wos/woscc/basic-search)

**Course Prerequisites**

Physics in M. Sc. I Year.