# IK Gujral Punjab Technical University, Kapurthala
## Department of Physical Sciences

Ref No.: IKGPTU/PS/ 1990 Date: 15/04/2019.

**Subject: Proceedings of the Board of Studies (BoS), Physical Sciences (Material Science/Nano Science and Technology) meeting held on 29.03.2019.**

A meeting of members of Board of Studies (BoS), Physical Sciences (Material Science/Nano Science and Technology) was held on 29.03.2019 in the Department of Physical Sciences, I K Gujral Punjab Technical University, Kapurthala. The agenda of the meeting was discussed in detail and recommendations were made on point. The proceedings of the meetings were recorded in the minutes of the meeting as enclosed as an Annexure -1.

Submitted for necessary action.

Convener- BoS
Dr. Neetika

Chairman, Board of Studies
Head, Physical Sciences.

# I.K. Gujral Punjab Technical University, Kapurthala

## Department of Physical Sciences

Ref.No.: IKGPTU/PS/1989 Date: 15/04/2019

### Minutes of Meeting

A meeting of members of Board of Studies (BoS), Physical Sciences (Material Science/Nano Science and Technology) was held on 29.03.2019 in the Department of Physical Sciences, I K Gujral Punjab Technical University, Kapurthala.

**Following members of BOS and special invitees were present and actively participated in discussion:**

1. Dr. Amit Sarin (Chairperson)
2. Dr. R. K. Bedi, Member
3. Dr Rakesh Dogra, Member
4. Dr. Hitesh Sharma, Member
5. Dr. Gaurav Bhargava, (Special invitee)
6. Dr. Maninder Kaur, Member
7. Dr. Jagmeet Bawa, (Special invitee)
8. Dr. Priyanka Mahajan, (Special invitee)
9. Dr. Sarabjit Singh Mann, (Special invitee)
10. Dr. Varinderjit Singh (Special invitee)
11. Dr. Neetika (Special invitee)
12. S. Navdeepak Sandhu, Member
13. Mr. Gurcharan Singh, M.Sc. (2nd Year)-Student representative
14. Mr. Nikhil M.Sc. (2nd Year)-Student representative

The following members could not attend the meeting:

1. Dr. Davinder Mehta, Member
2. Dr. Harpreet Kaur Grewal, Member
3. Dr. Kanchan L Singh, Member
4. Dr. B D Gupta, Member
5. Dr. Rajiv Malhotra, Member
6. Dr. P. Arumugam, Member
7. Dr. Ravi Kumar, Member
8. Dr. Arvind Kumar, Member
9. Dr. Ranjan Kumar, Member
10. Dr. Ashish Arora, (Special invitee)

The Board of Studies discussed on all the agenda points and following recommendations were made:

**Agenda item 1: To consider the revision of Program Educational objectives (PEO), Program outcomes (POs), Program specific outcomes (PSOs) and Course outcomes of M.Sc. (Physics) course**

All BoS members discussed the Program Educational objectives (PEO), Program outcomes (POs), Program specific outcomes (PSOs) of the M.Sc. (Physics) course and with vision of the Department of Physical Sciences. After incorporating suggestions, BOS members recommended the Program Educational objectives (PEO), Program outcomes (POs), Program specific outcomes (PSOs) and Course outcomes (COs) of various subjects for M.Sc. (Physics) w.e.f. 2018-19. **The copy of revised scheme and syllabus with revised PEOs, POs, PSOs, and COs is enclosed as Annexure A**.

**Agenda item 2: To consider the syllabus of inter disciplinary value-added course on Personality Development for Main Campus**

All BoS members discussed the syllabus of inter disciplinary value-added course on Personality Development for M.Sc. Physics students. The syllabus for audit course is designed by the Dr. Priyanka Mahajan. Board members agreed that more interdisciplinary course on Human values, Management, etc., may be added in near future. The copy of finalized syllabus of Personality Development is enclosed as Annexure-B.

**Agenda item 3: To consider the study scheme and syllabus of B. Sc. (Hons) Physics for the first two semesters in the academic session 2019-2020**

All BoS members discussed the study scheme of B Sc. (Hons) Physics and syllabus of 1$^{st}$ and 2$^{nd}$ semester starting from the academic session 2019-2020 in the IKGPTU Main Campus. Board members agreed that two physics core courses with their respective labs will be offered in first two semesters. Proposed study scheme and physics courses syllabus is attached here as Annexure-C. Further subject codes and open elective subjects will be discussed in the next BOS meeting.

**Agenda item 4: To consider the courses on skill and employability enhancement related.**

All BoS members discussed and recommended that theory and lab courses on Mathematical Physics, Electronics, Computational, Statistical, Nuclear, Condensed matter, Renewable energies, and Dissertation are essential for the employability enhancement of M.Sc. Physics students.

**Agenda item 5: To consider syllabus of new courses in PhD Course works**

All BoS members discussed and recommended the syllabus of new courses on 1) Advanced Particle Physics and 2) Renewable Energy Resources in the Curriculum of Ph. D course work as per the specialization available in the Department of Physical Sciences. The copy of approved syllabus of Advance Particle Physics and Renewable Energy Resources is enclosed as Annexure-D.

Dr. Amit Sarin
Chairperson- BoS, Physical Sciences

Dean Academics

Annexure-A

# M.Sc. Physics

## Course Structure and Syllabus
## (Based on Choice Based Credit System)
## 2018 onwards

# IK Gujral Punjab Technical University

## VISION

To be an institution of excellence in the domain of higher technical education that serves as the fountainhead for nurturing the future leaders of technology and techno- innovation responsible for the techno-economic, social, cultural and environmental prosperity of the people of the State of Punjab, the Nation and the World

## MISSION

- To provide seamless education through the pioneering use of technology, in partnership with industry and society with a view to promote research, discovery and entrepreneurship and
- To prepare its students to be responsible citizens of the world and the leaders of technology and techno-innovation of the 21st Century by developing in them the desirable knowledge, skill and attitudes base for the world of work and by instilling in them a culture for seamlessness in all facets of life.

## OBJECTIVES

- To offer globally-relevant, industry-linked, research-focused, technology- enabled seamless education at the graduate, postgraduate and research levels in various areas of engineering & technology and applied sciences keeping in mind that the manpower so spawned is excellent in quality, is relevant to the global technological needs, is motivated to give its best and is committed to the growth of the Nation;
- To foster the creation of new and relevant technologies and to transfer them to industry for effective utilization;
- To participate in the planning and solving of engineering and managerial problems of relevance to global industry and to society at large by conducting basic and applied research in the areas of technologies;

- To develop and conduct continuing education programmes for practicing engineers and managers with a view to update their fundamental knowledge base and problem-solving capabilities in the various areas of core competence of the University;
- To develop strong collaborative and cooperative links with private and public sector industries and government user departments through various avenues such as undertaking of consultancy projects, conducting of collaborative applied research projects, manpower development programmes in cutting-edge areas of technology, etc;
- To develop comprehensive linkages with premier academic and research institutions within the country and abroad for mutual benefit;
- To provide leadership in laboratory planning and in the development of instructional resource material in the conventional as well as in the audio-visual, the video and computer-based modes;
- To develop programmes for faculty growth and development both for its own faculty as well as for the faculty of other engineering and technology institutions;
- To anticipate the global technological needs and to plan and prepare to cater to them;
- To interact and participate with the community/society at large with a view to inculcate in them a feel for scientific and technological thought and endeavour; and
- To actively participate in the technological development of the State of Punjab through the undertaking of community development programmes including training and education programmes catering to the needs of the unorganized sector as well as that of the economically and socially weaker sections of society.

## ACADEMIC PHILOSOPHY

The philosophy of the education to be imparted at the University is to awaken the **"deepest potential"** of its students as holistic human beings by nurturing qualities of self-confidence, courage, integrity, maturity, versatility of mind as well as a capacity to face the challenges of tomorrow so as to enable them to serve humanity and its highest values in the best possible way.

# DEPARTMENT OF PHYSICAL SCIENCES

## VISION

To be a knowledge nerve center in Physical Sciences, Pure and Applied Research and industry requirements for creating sustainable infrastructure and enhancing quality of life

## MISSION

1. To offer globally-relevant, industry-linked, research-focused, technology-enabled seamless education at the graduate, postgraduate and research levels in various areas of Physical sciences keeping in mind that the manpower so spawned is excellent in quality, is relevant to the global scientific and technological needs, is motivated to give its best and is committed to the growth of the Nation;
2. To develop and conduct continuing education programmes for Science graduates with a view to update their fundamental knowledge base and problem-solving capabilities in the various areas of core specialization of the University;
3. To develop comprehensive linkages with premier academic and research institutions within the country and abroad for mutual benefit.

# M.Sc. (Physics) Program

**Duration: 2 Years (Semester System)**

This M.Sc. (Physics) Program includes various core, electives, and other interdisciplinary courses. The diverse lab experiments allow students to understand the fundamental aspects of the subject. A choice of advanced elective courses offers a glimpse in the frontier areas of research and allow students to work on research project as an integral part of their M.Sc. program. The program also provides adequate exposure to the students for pursuing higher education in the field of technology, research and development in Physics and related areas (M.Phil./Ph.D.) and other job opportunities in academia and industry.

**Eligibility:**

Pass B.Sc. with 50% marks having Physics as one of the subject. A relaxation of 5% is given in case of candidates belonging to SC/ST category.

**PROGRAM EDUCATIONAL OBJECTIVES:** At the end of the program, the student will be able to:

| | |
|---|---|
| PEO1 | Apply principles of basic scientific concepts in understanding, analysis, and prediction of physical systems. |
| PEO2 | To develop human resource with specialization in theoretical and experimental techniques required for career in academia, research and industry. |
| PEO3 | Engage in lifelong learning and adapt to changing professional and societal needs. |

**PROGRAM OUTCOMES:** At the end of the program, the student will be able to:

| | |
|---|---|
| PO1 | Apply the scientific knowledge to solve the complex physics problems. |
| PO2 | Identify, formulate, and analyze advanced scientific problems reaching substantiated conclusions using first principles of mathematics, physical, and natural sciences. |
| PO3 | Design solutions for advanced scientific problems and design system components or processes that meet the specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal consideration. |
| PO4 | Use research-based knowledge and methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| PO5 | Create, select, and apply appropriate techniques, resources, and modern scientific tools to complex physics problems with an understanding of the limitations. |
| PO6 | Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues, and the consequent responsibilities relevant to the professional scientific practice. |
| PO7 | Understand the impact of the scientific solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| PO8 | Apply ethical principles and commit to the norms of scientific practice. |
| PO9 | Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO10 | Communicate effectively on scientific activities with the Scientific/Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| PO11 | Demonstrate knowledge and understanding of the scientific principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| PO12 | Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of scientific and technological change. |

**PROGRAM SPECIFIC OUTCOMES:** At the end of the program, the student will be able to:

| | |
|---|---|
| PSO1 | Understand the basic and advance concepts of different branches of physics. |
| PSO2 | Perform and design experiments in the areas of electronics, atomic, nuclear, condensed matter, and computational physics. |
| PSO3 | Apply the concepts of physics in specialized areas of condensed, nuclear, renewable energies, particle physics, etc., in industry, academia, research and day today life. |

**SEMESTER FIRST**

| Course Code | Course Title | Load Allocation | | | Marks Distribution | | Total Marks | Credits |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | Internal | External | | |
| MSPH411-18 | Mathematical Physics-I | 3 | 1 | - | 30 | 70 | 100 | 4 |
| MSPH412-18 | Classical Mechanics | 3 | 1 | - | 30 | 70 | 100 | 4 |
| MSPH413-18 | Quantum Mechanics-I | 3 | 1 | - | 30 | 70 | 100 | 4 |
| MSPH414-18 | Electronics | 3 | 1 | - | 30 | 70 | 100 | 4 |
| MSPH415-18 | Computational Physics | 3 | 1 | - | 30 | 70 | 100 | 4 |
| MSPH416-18 | Electronics Lab | - | - | 6 | 50 | 25 | 75 | 3 |
| MSPH417-18 | Computational Physics Lab-I | - | - | 6 | 50 | 25 | 75 | 3 |
| **TOTAL** | | 15 | 5 | 12 | 250 | 400 | 650 | 26 |

**SEMESTER SECOND**

| Course Code | Course Title | Load Allocation | | | Marks Distribution | | Total Marks | Credits |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | Internal | External | | |
| MSPH421-18 | Mathematical Physics-II | 3 | 1 | - | 30 | 70 | 100 | 4 |
| MSPH422-18 | Statistical Mechanics | 3 | 1 | - | 30 | 70 | 100 | 4 |
| MSPH423-18 | Quantum Mechanics-II | 3 | 1 | - | 30 | 70 | 100 | 4 |
| MSPH424-18 | Classical Electrodynamics | 3 | 1 | - | 30 | 70 | 100 | 4 |
| MSPH425-18 | Atomic and Molecular Physics | 3 | 1 | - | 30 | 70 | 100 | 4 |
| MSPH426-18 | Atomic, Nuclear, and Particle Physics Lab | - | - | 6 | 50 | 25 | 75 | 3 |
| MSPH427-18 | Computational Physics Lab-II | - | - | 6 | 50 | 25 | 75 | 3 |
| | **TOTAL** | 15 | 5 | 12 | 250 | 400 | 650 | 26 |

**L: Lectures T: Tutorial P: Practical**

## SEMESTER THIRD

| Course Code | Course Title | Load Allocation | | | Marks Distribution | | Total Marks | Credits |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | Internal | External | | |
| MSPH531-18 | Condensed Matter Physics | 3 | 1 | - | 30 | 70 | 100 | 4 |
| MSPH532-18 | Nuclear Physics | 3 | 1 | - | 30 | 70 | 100 | 4 |
| MSPH533-18 | Particle Physics | 3 | 1 | - | 30 | 70 | 100 | 4 |
| MSPH534-18<br>MSPH535-18<br>MSPH536-18 | Elective Subject-I | 3 | 1 | - | 30 | 70 | 100 | 4 |
| MSPH537-18<br>MSPH538-18<br>MSPH539-18 | Elective Subject-II | 3 | 1 | - | 30 | 70 | 100 | 4 |
| MSPH540-18 | Condensed Matter Physics Lab | - | - | 6 | 50 | 25 | 75 | 3 |
| | TOTAL | 15 | 5 | 6 | 200 | 375 | 575 | 23 |

## SEMESTER FOURTH

| Course Code | Course Title | Load Allocation | | | Marks Distribution | | Total Marks | Credits |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | Internal | External | | |
| MSPH541-18<br>MSPH542-18<br>MSPH543-18 | Elective Subject-III | 3 | 1 | - | 30 | 70 | 100 | 4 |
| MSPH544-18<br>MSPH545-18<br>MSPH546-18 | Elective Subject-IV | 3 | 1 | - | 30 | 70 | 100 | 4 |
| MSPH547-18 | Dissertation | | 12 | | 200 | 100 | 300* | 12 |
| | TOTAL | 6 | 14 | | 260 | 240 | 500 | 20 |

*Evaluation criteria as and when adopted by IKGPTU

**TOTAL NUMBER OF CREDITS = 95**

## LIST OF DEPARTMENTAL/INTERDISCIPLINARY ELECTIVES

**Elective Subject-I**

| S. No. | Name of the Subject | Code |
|---|---|---|
| 1 | Fibre optics and non-linear optics | MSPH534-18 |
| 2 | Radiation Physics | MSPH535-18 |
| 3 | Nonlinear Dynamics | MSPH536-18 |

**Elective Subject -II**

| S.No. | Name of the Subject | Code |
|---|---|---|
| 1 | Plasma Physics | MSPH537-18 |
| 2 | Structures, Spectra and Properties of Biomolecules | MSPH538-18 |
| 3 | Science of Renewable Source of Energy | MSPH539-18 |

**Elective-III**

| S.No. | Name of the Subject | Code |
|---|---|---|
| 1 | Physics of Nanomaterials | MSPH541-18 |
| 2 | Experimental Techniques in Nuclear and Particle Physics | MSPH542-18 |
| 3 | Superconductivity and Low Temperature Physics | MSPH543-18 |

**Elective-IV**

| | Name of the Subject | Code |
|---|---|---|
| 1 | Advanced Condensed Matter Physics | MSPH544-18 |
| 2 | Advanced Particle Physics | MSPH545-18 |
| 3 | Environment Physics | MSPH546-18 |

**Examination and Evaluation**

| **Theory** | | | |
|---|---|---|---|
| **S. No.** | **Evaluation criteria** | **Weightage in Marks** | **Remarks** |
| 1 | Mid term/sessional Tests | 20 | Internal evaluation (20 Marks)<br>MSTs, Quizzes, assignments, attendance, etc., constitute internal evaluation. Average of two mid semester test will be considered for evaluation. |
| 2 | Attendance | 5 | |
| 3 | Assignments | 5 | |
| 4 | End semester examination | 70 | External evaluation (70 Marks)<br>Conduct and checking of the answer sheets will at the Department level in case of University teaching Department or Autonomous institutions.<br>For other colleges examination will be conducted at the University level. |
| 5 | Total | 100 | Marks may be rounded off to nearest integer. |
| **Practical** | | | |
| 1 | Evaluation of practical record/ Viva Voice | 30 | Internal evaluation (50 Marks) |
| 2 | Attendance | 5 | |
| 3 | Seminar/Presentation | 15 | |
| 4 | Final Practical Performance + Viva Voice | 25 | External evaluation (25 Marks) |
| 5 | Total | 75 | Marks may be rounded off to nearest integer. |

<table>
<tr><th colspan="7">Internal Assessment</th></tr>
<tr><td rowspan="2">Departmental Presentation</td><td colspan="2">Communication and presentation</td><td colspan="2">Response to queries</td><td>Maximum Marks</td><td>Evaluated by</td></tr>
<tr><td colspan="2">20</td><td colspan="2">30</td><td>50</td><td>Committee Member:<br>1.Head<br>2.Supervisor<br>3.One of Faculty Member</td></tr>
<tr><td rowspan="2">Dissertation</td><td>Plagiarism</td><td>Subject Matter</td><td>Usage of Language</td><td>Publication/Presentation in Conference</td><td rowspan="2">150</td><td rowspan="2"></td></tr>
<tr><td>25</td><td>70</td><td>25</td><td>30</td></tr>
<tr><th colspan="7">External Assessment</th></tr>
<tr><td rowspan="2">External Examiner</td><td colspan="4">Subject Matter</td><td rowspan="2">50</td><td rowspan="2"></td></tr>
<tr><td colspan="4">50</td></tr>
<tr><td rowspan="2">Viva Voce</td><td colspan="2">Communication and Presentation</td><td colspan="2">Response to queries</td><td rowspan="2">50</td><td rowspan="2">Committee Member:<br>1.Head<br>2.External Expert<br>3.Supervisor<br>4. Director (MC) nominee</td></tr>
<tr><td colspan="2">20</td><td colspan="2">30</td></tr>
<tr><td colspan="5">Total</td><td>300</td><td></td></tr>
</table>

**Evaluation Process:**

1. The subject matter evaluation can further be defined on the basis of Title, Review of literature/Motivation, Objectives, Methodology, Results and discussions, and Conclusion.
2. The usage of language and the subject matter shall be evaluated by the supervisor. Out of 300 marks, 95 marks are to be evaluated by the concerned supervisor.
3. Total 15% Plagiarism is admissible for submission of the dissertation. For (0-5)%of plagiarism, candidate should be awarded 25 marks. For >5%-10% candidate should be awarded 15 marks and for the range of > 10% to < 15%, candidate should be awarded 5 marks.
4. For publication candidate should be awarded full 30 marks and for presenting the work related to dissertation, candidate should be awarded 25 marks.

| MSPH411-18 | MATHEMATICAL PHYSICS-I | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** Understanding of graduate level mathematics

**Course Objectives:** The objective of the course on **Mathematical Physics-I** is to equip the M.Sc. students with the mathematical techniques that he/she needs for understanding theoretical treatment in different courses taught in this class and for developing a strong background if he/she chooses to pursue research in physics as a career.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Use complex variables for solving definite integral. |
| **CO2** | Use the Delta and Gamma functions for describing physical systems. |
| **CO3** | Solve partial differential equations using boundary value problems. |
| **CO4** | Describe special functions and recurrence relations to solve the physics problems. |
| **CO5** | Use statistical methods to analyse the experimental data. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 2 | - | 1 | 1 | - | 2 | 1 | 1 | 2 |
| **CO2** | 3 | 3 | 2 | 1 | - | 1 | 1 | - | 2 | 1 | 1 | 2 |
| **CO3** | 3 | 3 | 2 | 2 | - | 1 | 1 | - | 2 | 1 | 1 | 2 |
| **CO4** | 3 | 3 | 2 | 2 | - | 1 | 1 | - | 2 | 1 | 1 | 2 |
| **CO5** | 3 | 3 | 2 | 3 | - | 2 | 1 | - | 2 | 1 | 1 | 2 |

**Detailed Syllabus:**

1. **Complex Variables**: Introduction, Cauchy-Riemann conditions, Cauchy's Integral formula, Laurent expansion, singularities, calculus of residues, evaluation of definite integrals, Dispersion relation. *(Lectures 10)*

2. **Delta and Gamma Functions:** Dirac delta function, Delta sequences for one dimensional function, properties of delta function, Gamma function, factorial notation and applications, Beta function. *(Lectures 7)*

3. **Differential Equations:** Partial differential equations of theoretical physics, boundary value, problems, Neumann & Dirichlet Boundary conditions, separation of variables, singular points, series solutions, second solution. *(Lectures 8)*

4. **Special Functions:** Bessel functions of first and second kind, Generating function, integral representation and recurrence relations for Bessel's functions of first kind, orthogonality. Legendre functions: generating function, recurrence relations and special properties, orthogonality, various definitions of Legendre polynomials, Associated Legendre functions: recurrence relations, parity and orthogonality, Hermite functions, Laguerre functions. *(Lectures 10)*

5. **Elementary Statistics:** Introduction to probability theory, random variables, Binomial, Poisson and Normal distribution. *(Lectures 5)*

**Text Books:**

1. Mathematical Methods for Physicists: G. Arfken and H.J. Weber (Academic Press, SanDiego) 7th edition, 2011.

**Reference Books:**

1. Mathematical Physics: *P.K. Chattopadhyay (Wiley Eastern, New Delhi), 2004.*
2. Mathematical Physics: *A.K. Ghatak, I.C. Goyal and S.J. Chua (MacMillan, India, Delhi),1986.*
3. Mathematical Methods in the Physical Sciences – *M.L. Boas (Wiley, New York) 2rd edition, 2007.*
4. Special Functions: *E.D. Rainville (MacMillan, New York), 1960.*
5. Mathematical Methods for Physics and Engineering: *K.F. Riley, M.P. Hobson and S.J. Bence (Cambridge University Press, Cambridge) 2rd ed., 2006.*

| MSPH412-18 | CLASSICAL MECHANICS | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** Understanding of graduate level physics

**Course Objectives:** The aim and objective of the course on **Classical Mechanics** is to train the students of M.Sc. students in the Lagrangian and Hamiltonian formalisms so that they can use these in the modern branches of physics such as Quantum Mechanics, Quantum Field Theory, Condensed Matter Physics, Astrophysics, etc.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Understand the necessity of Action, Lagrangian, and Hamiltonian formalism. |
| **CO2** | Use d'Alambert principle and calculus of variations to derive the Lagrange equations of motion. |
| **CO3** | Describe the motion of a mechanical system using Lagrange-Hamilton formalism. |
| **CO4** | Apply essential features of a classical problem (like motion under central force, periodic motions) to set up and solve the appropriate physics problems. |
| **CO5** | Appreciate the theory of rigid body motion which is important in several areas of physics e.g., molecular spectra, acoustics, vibrations of atoms in solids, coupled mechanical oscillators, electrical circuits, etc.. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 2 | 2 | 1 | 1 | - | 2 | 2 | 2 | 2 |
| **CO2** | 3 | 2 | 2 | 2 | 2 | 1 | 1 | - | 2 | 2 | 2 | 2 |
| **CO3** | 3 | 2 | 2 | 2 | 2 | 1 | 1 | - | 2 | 2 | 2 | 2 |
| **CO4** | 3 | 2 | 2 | 2 | 1 | 1 | 1 | - | 2 | 2 | 2 | 2 |
| **CO5** | 3 | 2 | 2 | 2 | 1 | 1 | 1 | - | 2 | 2 | 2 | 2 |

**Detailed Syllabus:**

1. **Lagrangian Formulation:** Mechanics of a system of particles; constraints of motion, generalized coordinates, d'Alembert Principle and Lagrange's velocity-dependent forces and the dissipation function, Applications of Lagrangian formulation.
*(Lectures 7)*
2. **Hamilton's Principles:** Calculus of variations, Hamilton's principle, Lagrange's equation from Hamilton's principle, extension to nonholonomic systems, advantages of variational principle formulation, symmetry properties of space and time and conservation theorems.
*(Lectures 7)*

3. **Hamilton's Equations:** Legendre Transformation, Hamilton's equations of motion, Cyclic coordinates, Hamilton's equations from variational principle, Principle of least action.
*(Lectures 7)*
4. **Canonical Transformation and Hamilton-Jacobi Theory:** Canonical transformation and its examples, Poisson's brackets, Equations of motion, Angular momentum, Poisson's Bracket relations, infinitesimal canonical transformation, Conservation Theorems. Hamilton- Jacobi equations for principal and characteristic functions, Action-angle variables for systems with one-degree of freedom. *(Lectures 10)*

5. **Rigid Body Motion:** Independent co-ordinates of rigid body, orthogonal transformations, Eulerian Angles and Euler's theorem, infinitesimal rotation, Rate of change of a vector, Coriolis force, angular momentum and kinetic energy of a rigid body, the inertia tensor, principal axis transformation, Euler equations of motion, Torque free motion of rigid body, motion of a symmetrical top. *(Lectures 10)*

**Text Books:**

1. Classical Mechanics*: H. Goldstein, C.Poole and J.Safko (Pearson Education Asia, New Delhi),* 2rd ed 2001.
2. Mechanics by L.D. Landau & E.M. Lifschz (Pergamon), 1976.

**Reference Books:**

3. Classical Mechanics of Particles and Rigid Bodies: *K.C. Gupta (Wiley Eastern, New Delhi), 1988.*
4. Classical Mechanics- J. W. Muller- Kirsten (World Scientific) 2008.
5. Advanced Classical & Quantum Dynamics by W. Dittrich, W. And M Reuter, M. (Springer) 1991.
6. Classical mechanics by T.W.B. Kibble and Frank H. Berkshire (Imperial College Press) 2004.
7. Mathematical Methods of Classical Mechanics by V. I. Arnold, (Springer) 1978.

| MSPH413-18 | Quantum Mechanics-I | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** Basic knowledge of wave mechanical quantum mechanics

**Course Objectives:** The aim and objective of the course on **Quantum Mechanics-I** is to introduce the students of M.Sc. class to the formal structure of the subject and to equip them with the techniques of vector spaces, angular momentum, perturbation theory, and scattering theory so that they can use these in various branches of physics as per their requirement.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| CO1 | Understand the need for quantum mechanical formalism and its basic principles. |
| CO2 | Appreciate the importance and implication of vector spaces, Dirac ket bra notations, eigen value problems, generalized uncertainty principle in QM. |
| CO3 | Better understanding of the mathematical foundations of spin and angular momentum for a system of particles. |
| CO4 | Solve Schrodinger equation for various QM systems using approximate methods. |
| CO5 | Apply perturbation theory to scattering matrix and partial wave analysis. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 3 | 2 | 2 |
| **CO2** | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 |
| **CO3** | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 3 | 2 | 2 |
| **CO4** | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO5** | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 3 | 2 | 2 |

**Detailed Syllabus:**

1. **Linear Vector Space and Matrix Mechanics:** Vector spaces, Schwarz inequality, Orthonormal basis, Operators: Projection operator, Hermitian and Unitary operators, change of basis, Eigenvalue and Eigenvectors of operators, Dirac's bra and ket notation, commutators, Simultaneous eigenvectors, Postulates of quantum mechanics, uncertainty relation, Harmonic oscillator in matrix mechanics, Time development of states and operators, Heisenberg, Schroedinger and Interaction representations, Exchange operator and identical particles, Density Matrix and Mixed Ensemble. *(Lectures 12)*

2. **Angular Momentum:** Angular part of the Schrödinger equation for a spherically symmetric potential, orbital angular momentum operator. Eigen values and eigenvectors of $L^2$ and Lz. Spin angular momentum, General angular momentum, Eigen values and eigenvectors of $J^2$ and Jz. Representation of general angular momentum operator, Addition of angular momenta, C.G. coefficients. *(Lectures 7)*

3. **Stationary State Approximate Methods:** Non-Degenerate and degenerate perturbation theory and its applications, Variational method with applications to the ground states of harmonic oscillator and other sample systems. *(Lectures 7)*

4. **Time Dependent Perturbation:** General expression for the probability of transition from one state to another, constant and harmonic perturbations, Fermi's golden rule and its application to radiative transition in atoms, Selection rules for emission and absorption of light. *(Lectures 7)*

5. **Scattering Theory:** Scattering Cross-section and scattering amplitude, partial wave analysis, Low energy scattering, Green's functions in scattering theory, Born approximation and its application to Yukawa potential and other simple potentials. Optical theorem, Scattering of identical particles. *(Lectures 7)*

**Text Books:**

1. A Text book of Quantum Mechanics: P.M. Mathews and K. Venkatesan (Tata McGraw Hill, New Delhi) 1nd edition, 2004.
2. Quantum Mechanics: V.K. Thankappan (New Age, New Delhi), 2004.

**Reference Books:**

1. Quantum Mechanics: M.P. Khanna, (Har Anand, New Delhi), 2006.
2. Modern Quantum Mechanics: J.J. Sakurai (Addison Wesley, Reading), 2004.
3. Quantum Mechanics: J.L. Powell and B. Crasemann (Narosa, New Delhi), 1995.
4. Quantum Physics: S. Gasiorowicz (Wiley, New York), 2rd ed. 2002.
5. Quantum Physics: Concepts and Applcations: Nouredine Zettili (Wiley, New York), 2nd ed. 2009.

| **MSPH414-18** | **Electronics** | L-3, T-1, P-0 | **4 Credits** |
|---|---|---|---|

**Pre-requisite:** Basic knowledge about electronics

**Course Objectives:** The aim and objective of the course on Electronics is to introduce the students of M.Sc. class to the formal structure of the subject and to equip them with the knowledge of semiconductor physics, basic circuit analysis, first-order nonlinear circuits, OPAMP based analog circuits and introduction to digital electronics so that they can use these in various branches of physics as per their requirement.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| CO1 | Understand working of Different Semiconductor devices (Construction, Working Principles and V-I characteristics) and their applications. |
| CO2 | Explain the construction and working of Thyristors and use Thyristors for various applications. |
| CO3 | Design Analog and Digital Instruments and their applications. |
| CO4 | Apply Boolean algebra and Karnaugh maps. |
| CO5 | Design the Sequential and Integrated circuits. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO2** | 3 | 3 | 2 | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO3** | 2 | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO4** | 3 | 3 | 2 | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO5** | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 |

**Detailed Syllabus:**

1. **Semiconductor Devices and applications:** Direct and indirect semiconductors, Drift and diffusion of carriers, Photoconductors, Semiconductor junctions, Metal-semiconductor junctions - Ohmic and rectifying contacts, Zener diode, Schottky diode, Switching diodes, Tunnel diode, Light emitting diodes, Photodiodes, Solar cell, Liquid crystal displays. *(Lectures 7)*
2. **UJTs and Thyristors:** Operational Principle of UJT: UJT Relaxation Oscillator circuit; PNPN Diode: Characteristics- As a Relaxation Oscillator-Rate Effect; SCR: V-I Characteristics-Gate Triggering Characteristics; DIAC and TRIAC; Thyristors: Basic Parameters- As Current Controllable Devices- Thyristors in Series and in Parallel; Applications of Thyristors- as a Pulse Generator, Bistable Multivibrator, Half and Full Wave Controlled Rectifier, TRIAC based AC power control, SCR based Crowbar Protection; Gate Turn-Off Thyristors; Programmable UJT. *(Lectures 10)*
3. **Analog and Digital Instruments:** OPAMP and its applications, Time Base; 555 Timer, Basic Digital Frequency Meter System; Reciprocal Counting Technique; Digital Voltmeter System. *(Lectures 8)*
4. **Digital circuits:** Boolean algebra, de Morgans theorem, Karnaugh maps. *(Lectures 5)*
5. **Sequential circuits:** Flip-Flops – RS, JK, D, COcked, preset and clear operation, race around conditions in JK Flip-flops, master-slave JK flip-flops, Switch contact bounce circuit. Shift registers, Asynchronous and Synchronous counters, Counter design and applications. *(Lectures8)*
6. **Integrated Circuits as Digital System Building Blocks:** Binary Adders: Half Adder-Parallel Operation-Full Adder-MSI Adder-Serial Operation; Decoder/Demultiplexer: BCD to Decimal Decoder-4-to-16 line Demultiplexer; Data Selector/Multiplexer:16-to-1 Multiplexer; Encoder; ROM: Code Converters-Programming the ROM-Applications; RAM:Linear Selection-Coincident Selection-Basic RAM Elements Bipolar RAM-Static and Dynamic MOS RAM; Digital to Analog Converters: Ladder Type D/A Converter-Multiplying D/A Converter; Analog to Digital Converters: Successive Approximation A/D Converter. *(Lectures 8)*

**Text Books:**

1. Text Book of Electronics: *S. Chattopadhyay,* New Central Book Agency P.Ltd., Kolkata, 2006.
2. Digital Principles and Applications: *A.P. Malvino and D.P. Leach,* Tata McGraw-Hill, Publishing Co., New Delhi.

**Reference Books:**

1. Electronics Principles and Applications: *A.B. Bhattacharya*, New Central Book Agency P.Ltd., Kolkata, 2007.
2. Integrated Electronics Analog and Digital Circuits and Systems: *J. Millman, C.C Halkins and C. Parikh*, 1nd Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2010.

| MSPH415-18 | Computational Physics | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** Understanding of graduate level physics

**Course Objectives:** The aim and objective of the course on **Computational Physics** is to familiarize the students of M.Sc. students with the numerical methods used in computation and programming using any high level language such as Fortran, C++, etc., so that they can use these in solving simple physics problems.

**Course Outcomes:** At the end of the course the student will be able to

| | |
|---|---|
| CO1 | Apply basics knowledge of computational physics in solving the physics problems. |
| CO2 | Programme with the C++ or any other high level language. |
| CO3 | Use various numerical methods in solving physics problems. |
| CO4 | Analyze the outcome of the algorithm/program graphically. |
| CO5 | Simulate the physical systems using simulations. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 2 | 3 | 2 | 3 | 2 |
| **CO2** | 3 | 3 | 3 | 1 | 2 | 1 | 1 | 1 | 3 | 2 | 3 | 2 |
| **CO3** | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO4** | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO5** | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 |

**Detailed Syllabus:**

1. **Introduction to Computational Physics:** Need and advantages of high level language in physics, programming in a suitable high level language (Matlab/Mathematica/Scilab/Octave), input/output, interactive input, loading and saving data, loops branches and control flow, Matrices and Vectors, Matrix and array operations, Graphic tools: Gnuplots, Origin, Sigmaplot, Visual Molecular Dynamics, Mathematica, etc. *(Lectures 11)*

2. **Programming with C++:** Introduction to the Concept of Object Oriented Programming; Advantages of C++ over conventional programming languages; Introduction to Classes, Objects; C++ programming syntax for Input/Output, Operators, Loops, Decisions, simple and inline functions, arrays, strings, pointers; some basic ideas about memory management in C+. *(Lectures 15)*

3. **Numerical methods:** Computer algorithms, interpolations-cubic spline fitting, Numerical differentiation – Lagrange interpolation, Numerical integration by Simpson and Weddle's rules, Random number generators, Numerical solution of differential equations by Euler, predictor-corrector and Runge-Kutta methods, eigenvalue problems, Monte Carlo simulations. *(Lectures15)*

**Text Books:**

1. Numerical Mathematical Analysis, J.B. Scarborough (Oxford & IBH Book Co.) 6th ed., 1979.
2. A first course in Computational Physics: P.L. DeVries (Wiley) 1nd edition, 2011.

**Reference Books:**

1. Computer Applications in Physics: S. Chandra (Narosa) 1nd edition, 2005.
2. Computational Physics: R.C. Verma, P.K. Ahluwalia and K.C. Sharma (New Age) 2000.
3. Object Oriented Programming with C++: Balagurusamy, (Tata McGrawHill) 4th edition 2008.

| MSPH416-18 | Electronics Lab | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** Understanding of graduate level physics experiments

**Course Objectives:** The aim and objective of the laboratory on Electronics Lab is to expose the students of M.Sc. class to experimental techniques in electronics so that they can verify some of the things read in theory here or in earlier classes and develop confidence to handle sophisticated equipment.

**Course Outcomes:** At the end of the course, the student will

| | |
|---|---|
| CO1 | Acquire hands on experience of handling and building electronics circuits. |
| CO2 | Be familiar with the various components such as resistors, capacitor, inductor, IC chips and how to use these components in circuits. |
| CO3 | Be able to understand the construction, working principles and V-I characteristics of various devices such as PN junction diodes, UJT, TRIAC, etc. |
| CO4 | Capable of using components of digital electronics for various applications. |
| CO5 | Able to design and perform scientific experiments as well as accurately record and analyze the results of experiments. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 2 |
| **CO2** | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 |
| **CO3** | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| **CO4** | 2 | 2 | 2 | 2 | 2 | 3 | 1 | 2 | 2 | 2 | 2 | 2 |
| **CO5** | 3 | 2 | 3 | 3 | 2 | 3 | 1 | 2 | 2 | 2 | 2 | 2 |

**Detailed Syllabus:**

**Note: Students are expected to perform atleast 10 experiments out of following list.**

1. Study the forward and reverse characteristics of a Semiconctor/Zener diode.
2. Construction of adder, subtracter, differentiator and integrator circuits using the given OP-Amp.
3. Study the static and drain characteristics of a JFET.
4. Construction of an Astable multivibrator circuit using transistor.
5. Construction of a single FET amplifier with common source configuration.
6. To study the operation of Analog to Digital convertor.
7. To study the operation of Digital to Analog convertor.
8. Construction of a low-pass filter circuit and study its output performance.
9. Construction of a high-pass filter circuit and study its output performance.
10. To verify the Dmorgan's law using Logic Gates circuit.
11. To study the Characteristics of Tunnel Diode.
12. To study Amplitude Modulation.
13. To study Frequency Modulation.
14. To study the Characteristics of SCR.
15. To study the Characteristics of MOSFET.
16. To study the Characteristics of UJT.
17. To study the Characteristics of TRIAC.
18. To verify the different Logic and Arithmetic operations on ALU system.
19. To study the operation of Encoders and Decoders.
20. To study the operation of Left and right shift registers.
21. To study the operation of Counters, Ring counters.
22. To determine the thermal coefficient of a thermistor.
23. To study the operation of an Integrated Circuit Timer.

**Text Books:**

1. Text Book of Electronics: *S. Chattopadhyay,* New Central Book Agency P.Ltd., Kolkata, 2006.
2. Digital Principles and Applications: *A.P. Malvino and D.P. Leach,* Tata McGraw-Hill, Publishing Co., New Delhi.

**Reference Books:**

1. Electronics Principles and Applications: *A.B. Bhattacharya*, New Central Book Agency P.Ltd., Kolkata, 2007.
2. Integrated Electronics Analog and Digital Circuits and Systems: *J. Millman, C.C Halkins and C. Parikh*, 1ndEdition, Tata McGraw Hill Education Private Limited, New Delhi, 2010.

| MSPH417-18 | Computational Physics Lab-I | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** Understanding of graduate level numerical methods

**Course Objectives:** The aim and objective of the course on **Computational Physics Lab-I** is to familiarize the of M.Sc. students with the numerical methods used in computation and programming using C++ language so that they can use these in solving simple problems pertaining to physics.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Apply basics knowledge of computational Physics in solving various physical problems. |
| **CO2** | Programme with the C++ or any other high level language. |
| **CO3** | Use various numerical methods in describing/solving physics problems. |
| **CO4** | Solve problem, critical thinking and analytical reasoning as applied to scientific problems. |
| **CO5** | Analyse and reproduce the experimental data. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 2 | 3 | 2 | 3 | 2 |
| **CO2** | 3 | 3 | 3 | 1 | 2 | 1 | 1 | 1 | 3 | 2 | 3 | 2 |
| **CO3** | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO4** | 3 | 3 | 2 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **CO5** | 1 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 |

**Detailed Syllabus:**

**Note: Students are expected to perform atleast 10 experiments out of following list.**

1. To find the standard deviation, mean, variance, moments etc. of at least 15 entries.
2. To choose a set of 10 values and find the least squared fitted curve.
3. Find y for a given x by fitting a set of values with the help of cubic spline fitting technique.
4. To find the Roots of an Algebraic Equation by Bisection method and secant method
5. To find the Roots of an Algebraic Equation by Newton-Raphson Method.
6. To find the Roots of Linear Equations by Gauss Elimination Method.
7. To find the Roots of Linear Equations by Gauss-Seidal Iterative Method.
8. Find first order derivative at given x for a set of values with the help of Lagrange interpolation.
9. To perform numerical integration of a function by Trapezoidal Rule.
10. To perform numerical integration of a function by Simpson's Rule.
11. To perform numerical integration of a function by Weddle's rule.
12. To solve a Differential Equation by Euler's method and Modified Euler's Method.
13. To solve a Differential Equation by Runge Kutta method.
14. To find the determinant of a matrix and its eigenvalues and eigenvectors.
15. To generate random numbers between (i) 1 and 0, (ii) 1 and 100.

**Text Books:**

1. Numerical Mathematical Analysis, J.B. Scarborough (Oxford & IBH Book Co.) 6th ed., 1979.
2. A first course in Computational Physics: P.L. DeVries (Wiley) 1nd edition, 2011.

**Reference Books:**

1. Computer Applications in Physics: S. Chandra (Narosa) 1nd edition, 2005.
2. Computational Physics: R.C. Verma, P.K. Ahluwalia and K.C. Sharma (New Age) 2000.
3. Object Oriented Programming with C++: Balagurusamy, (Tata McGrawHill) 4th edition 2008.

| **MSPH421-18** | **Mathematical Physics-II** | L-3, T-1, P-0 | **4 Credits** |
|---|---|---|---|

**Pre-requisite: Understanding of graduate level mathematics**

**Course Objectives:** The aim and objective of the course on **Mathematical Physics-II** is to equip the M.Sc. Students with the mathematical techniques that he/she needs for understanding theoretical treatment in different courses taught in this class and for developing a strong background if he/she chooses to pursue research in physics as a career.

**Course Outcomes:** At the end of the course, the student will able to

| | |
|---|---|
| **CO1** | Understand the basics and aplications of group theory in all the branches of Physics. |
| **CO2** | Use Fourier series and transformations as an aid for analyzing physical problems. |
| **CO3** | Apply integral transform to solve mathematical problems of Physics interest. |
| **CO4** | Formulate and express a physical law in terms of tensors and simplify it by use of coordinate transforms. |
| **CO5** | Develop mathematical skills to solve quantitative problems in physics. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 2 | - | 1 | 1 | - | 2 | 1 | 1 | 2 |
| **CO2** | 3 | 3 | 2 | 2 | - | 1 | 1 | - | 2 | 1 | 1 | 2 |
| **CO3** | 3 | 3 | 2 | 2 | - | 1 | 1 | - | 2 | 1 | 1 | 2 |
| **CO4** | 3 | 3 | 2 | 2 | - | 1 | 1 | - | 2 | 1 | 1 | 2 |
| **CO5** | 3 | 3 | 2 | 2 | - | 1 | 1 | - | 2 | 1 | 1 | 2 |

**Detailed Syllabus:**

1. **Group Theory:** What is a group? Multiplication table, conjugate elements and classes, subgroups, Isomorphism and Homomorphism, Definition of representation and its properties, Reducible and irreducible representations, Schur's lemmas (only statements), characters of a representation. Example of C4v, Topological groups and Lie groups, three dimensional rotation group, special unitary groups SU(1) and SU(2). *(Lectures 10)*

2. **Tensors:** Introduction, definitions, contraction, direct product. Quotient rule, Levi-Civita symbol, Noncartesian tensors, metric tensor, Covariant differentiation. *(Lectures 7)*

3. **Fourier Series and Integral Transforms:** Fourier series, Dirichlet conditions, General properties, Advantages and applications, Gibbs phenomenon, Fourier transforms, Development of the Fourier integral, Inversion theorem, Fourier transforms of derivatives; Momentum representation, Laplace transforms, Laplace transforms of derivatives, Properties of Laplace transform, Inverse Laplace transformation. *(Lectures 15)*

4. **Integral Equations:** Definitions and classifications, integral transforms and generating functions. Neumann series, Separable Kernels, Hilbert-Schmidt theory, Green's functions in one dimension. *(Lectures 10)*

**Text Books:**

1. Group Theory for Physicists. A.W. Joshi (Wiley Eastern, New Delhi) 2011.
2. Mathematical Methods for Physicists: G. Arfken and H.J. Weber. (Academic Press, San Diego) 7th edition, 2011.

**Reference Books:**

1. Matrices and Tensors in Physics: A.W. Joshi (Wiley Eastern, New Delhi) 2005.
2. Numerical Mathematical Analysis: J.B. Scarborough (Oxford Book Co., Kolkata) 4th edition.
3. A First Course in Computational Physics: P.L. Devries (Wiley, New York) 1994.
4. Mathematical Physics: P.K. Chatopadhyay (Wiley Eastern, New Delhi) 2011.
5. Introduction to Mathematical Physics: C. Harper (Prentice Hall of India, New Delhi) 2006.

| **MSPH422-18** | **Statistical Mechanics** | **L-3, T-1, P-0** | **4 Credits** |
|---|---|---|---|

**Pre-requisite: Understanding of graduate level statistical mechanics**

**Course Objectives:** The aim and objective of the course on **Statistical Mechanics** is to equip the M.Sc. student with the techniques of statistical ensemble theory so that he/she can use these to understand the macroscopic properties of the matter in bulk in terms of its microscopic constituents.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Find the connection between Statistical Mechanics and thermodynamics |
| **CO2** | Use ensemble theory to explain the behavior of Physical systems |
| **CO3** | Explain the statistical behavior of Bose-Einstein and Fermi-Dirac systems and their applications. |
| **CO4** | Work with models of phase transitions and thermo-dynamical fluctuations. |
| **CO5** | Describe physical problems using quantum statistics. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | - | 1 | - | - | - | - | - | 1 | 1 | - | - | - |
| **CO2** | 3 | 3 | 3 | 1 | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 1 |
| **CO3** | 3 | 3 | 3 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 |
| **CO4** | 3 | 3 | 3 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 |
| **CO5** | 3 | 3 | 3 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 |

**Detailed Syllabus:**

1. **The Statistical Basis of Thermodynamics:** The macroscopic and microscopic states, contact between statistics and thermodynamics, classical ideal gas, Gibbs paradox and its solution. *(Lectures 7)*

2. **Ensemble Theory:** Phase space and Liouville's theorem, the microcanonical ensemble theory and its application to ideal gas of monatomic particles; The canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations, equipartition and virial theorems, a system of quantum harmonic oscillators as canonical ensemble, statistics of paramagnetism; The grand canonical ensemble and significance of statistical quantities, classical ideal gas in grand canonical ensemble theory, density and energy fluctuations. *(Lectures 10)*

3. **Quantum Statistics of Ideal Systems:** Quantum states and phase space, an ideal gas in quantum mechanical ensembles, statistics of occupation numbers; Ideal Bose systems: basic concepts and thermodynamic behaviour of an ideal Bose gas, Bose-Einstein condensation, discussion of gas of photons (the radiation fields) and phonons (the Debye field); Ideal Fermi systems: thermodynamic behaviour of an ideal Fermi gas, discussion of heat capacity of a free electron gas at low temperatures, Pauli paramagnetism. *(Lectures 10)*

4. **Elements of Phase Transitions:** Introduction, a dynamical model of phase transitions, Ising model in zeroth approximation. *(Lectures 8)*

5. **Fluctuations:** Thermodynamic fluctuations, random walk and Brownian motion, introduction to non-equilibrium processes, diffusion equation. *(Lectures 5)*

**Text Books:**

1. Statistical Mechanics: R.K. Pathria and P.D. Beale (Butterworth-Heinemann, Oxford), 2$^{rd}$ edition, 2011.

**Reference Books:**

1. Statistical Mechanics: *K. Huang (Wiley Eastern, New Delhi), 1987.*
2. Statistical Mechanics: *B.K. Agarwal and M. Eisner (Wiley Eastern, New Delhi) 1nd edition, 2011.*
3. Elementary Statistical Physics: *C. Kittel (Wiley, New York), 2004.*
4. Statistical Mechanics: *S.K. Sinha (Tata McGraw Hill, New Delhi), 1990.*

| **MSPH423-18** | **Quantum Mechanics–II** | **L-3, T-1, P-0** | **4 Credits** |
|---|---|---|---|

**Pre-requisite:** Preliminary course of Quantum Mechanics

**Course Objectives:** The aim and objective of the course on **Quantum Mechanics-II** is to introduce the M.Sc. students to the formal structure of the subject and to equip him/her with the techniques of Relativistic quantum mechanics and Quantum field theory so that he/she can use these in various branches of physics as per his/her requirement.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Define the relativistic QM as the covariant formulation of quantum mechanics and need for quantum field theory |
| **CO2** | Give the significance of Klein Gordon and Dirac equation and existence of antiparticles. |
| **CO3** | Apply the symmetries principles and Noether's theorem in calculating the conserved currents and charges. |
| **CO4** | Demonstrate the second quantization for scalar, Dirac, and electromagnetic fields. |
| **CO5** | Explain the origin of Feynman diagrams and apply the Feynman rules to derive the amplitudes for elementary processes |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 2 |
| **CO2** | 2 | 2 | 3 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 2 |
| **CO3** | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 |
| **CO4** | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 2 |
| **CO5** | 2 | 2 | 3 | 2 | 1 | 1 | 2 | 2 | 2 | 1 | 2 | 2 |

**Detailed Syllabus:**

1. **Relativistic Quantum Mechanics-I:** Klein-Gordon equation, Dirac equation and its plane wave solutions, significance of negative energy solutions, spin angular momentum of the Dirac particle, the non-relativistic limit of Dirac equation.

   *(Lectures 10)*

2. **Relativistic Quantum Mechanics-II:** Electron in electromagnetic fields, spin magnetic moment, spin-orbit interaction, Dirac equation for a particle in a central field, fine structure of hydrogen atom, Lamb shift.

   *(Lectures 10)*

3. **Quantum Field Theory:** Resume of Lagrangian and Hamiltonian formalism of a classical field, Noether theorem, Quantization of real scalar field, complex scalar field, Dirac field and electromagnetic field, Covariant perturbation theory, Wick's theorem, Scattering matrix. *(Lectures 10)*

4. **Feynman diagrams**: Feynman rules, Feynman diagrams and their applications, Yukawa field theory, calculations of scattering cross-sections, decay rates with examples, Quantum Electrodynamics, calculations of matrix elements - for first order and second order.

   *(Lectures 10)*

**Text Books:**

1. Relativistic quantum Mechanics, J D Bjorken and S D Drell, (Tata McGraw Hill, New Delhi) 2012.
2. A first book of Quantum Field Theory, A. Lahiri & P. Pal, (Narosa Publishers, New Delhi), 1st ed. 2005.
3. Introduction to Quantum Field Theory, M. Peskin & D.V. Schroeder. (Levant Books) 2015.

**Reference Books:**

1. Quantum Field Theory in a Nutshell: A Zee (University Press), 2012.
2. *Lecture on Quantum Field Theory, A. Das (World Scientific), 2008.*
3. Text Book of Quantum Mechanics-*P.M. Mathews & K. Venkatesan (Tata McGraw Hill, New Delhi), 2004.*
4. Quantum Field Theory: H. Mandl and G. Shaw *(Wiley, New York)*, 2010.
5. Advance Quantum Mechanics: J.J. Sakurai *(Addison- Wesley, Reading)*, 2004.

| MSPH424-18 | Classical Electrodynamics | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** Understanding of graduate level electricity and magnetism

**Course Objectives:** The **Classical Electrodynamics** course covers Electrostatics and Magnetostatics including Maxwell equations, and their applications to propagation of electromagnetic waves in dielectrics; EM waves in bounded media, waveguides, Radiation from time varying sources.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| CO1 | Understand and apply the laws of electromagnetism and use Maxwell equations in different forms and different media. |
| CO2 | Explain the dynamics of charged bodies and radiation from localized time varying electromagnetic sources. |
| CO3 | Provide solution to real life plane wave problems for various boundary conditions for different charge configurations. |
| CO4 | Describe the propagation of electromagnetic waves and its propagation through different media types /configurations. |
| CO5 | To develop an understanding about the waveguides, and propagation of waves through different waveguides. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 3 |
| **CO2** | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 3 |
| **CO3** | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 3 |
| **CO4** | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 3 | 2 | 3 |
| **CO5** | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 3 | 2 | 3 |

**Detailed Syllabus:**

1. **Electrostatics:** Laplace and Poisson's equations, Electrostatic potential and energy density of the electromagnetic field, Multipole expansion of the scalar potential of a charge distribution, dipole moment, quadrupole moment, Multipole expansion of the energy of a charge distribution in an external field, Static fields in material media, Polarization vector, macroscopic equations, classification of dielectric media, Molecular polarizability and electrical susceptibility, Clausius-Mossetti relation, Models of Molecular polarizability, energy of charges in dielectric media (Maxwell stress tensor).
*(Lectures 10)*
2. **Magnetostatics:** The differential equations of magnetostatics, vector potential, magnetic fields of a localized current distribution, Singularity in dipole field, Fermi-contact term, Force and torque on a localized current distribution. (Magnetic stress tensor)
*(Lectures 8)*
3. **Boundary value problems:** Uniqueness theorem, Dirichlet and Neumann Boundary conditions, Earnshaw theorem, Green's (reciprocity) theorem, Formal solution of electrostatic boundary value problem with Green function, Method of images with examples, Magnetostatic boundary value problems. *(Lectures 8)*

4. **Time varying fields and Maxwell equations:** Faraday's law of induction, displacement current, Maxwell equations, scalar and vector potential, Gauge transformation, Lorentz and Coulomb gauges, Hertz potential, General expression for the electromagnetic fields energy, conservation of energy, Poynting Theorem, Conservation of momentum.
*(Lectures 8)*
5. **Electromagnetic Waves:** wave equation, plane waves in free space and isotropic dielectrics, polarization, energy transmitted by a plane wave, Poynting theorem for a complex vector field, waves in conducting media, skin depth, Reflection and refraction of e.m. waves at plane interface, Fresnel's amplitude relations, Reflection and Transmission coefficients, polarization by reflection, Brewster's angle, Total internal reflection, Stoke's parameters, EM wave guides, Cavity resonators, Dielectric waveguide, optical fibre waveguide. *(Lectures 10)*

**Text Books:**


1. Classical Electrodynamics: *S.P. Puri (Narosa Publishing House) 2011.*
2. Classical Electrodynamics*: J.D. Jackson, (New Age, New Delhi) 2009.*
3. Introduction to Electrodynamics: *D.J. Griffiths (Prentice Hall India, New Delhi) 4th ed., 2011.*


**Reference Books:**


1. Classical Electromagnetic Radiation: *J.B. Marion and M.A. Heald(Saunders College Publishing House) 2nd edition, 1995.*
2. Electromagnetic Fields, *Ronald K. Wangsness (John Wiley and Sons) 1nd edition,1986.*
3. Electromagnetic Field Theory Fundamentals: *Bhag Singh Guru and H.R. Hiziroglu*

| **MSPH425-18** | **Atomic and Molecular Physics** | **L-3, T-1, P-0** | **4 Credits** |
|---|---|---|---|

**Pre-requisite:** Understanding of graduate level spectroscopy

**Course Objectives:** The aim and objective of the course on **Atomic and Molecular Physics** for the students of M.Sc. Physics is to equip them with the knowledge of Atomic, Rotational, Vibrational, Raman, and Electronic spectra.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| CO1 | Have the basic knowledge of Bohr's- Sommerfeld Quantum theory of hydrogen like atom |
| CO2 | Understand classical/quantum description of electronic spectra of atom and molecules |
| CO3 | Use microwave and Raman Spectroscopy for analysis of known molecules |
| CO4 | Correlate infrared spectroscopic information of known molecules with their physical description |
| CO5 | Understand Spin Resonance Spectroscopy with focus on NMR for molecular analysis |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 2 | 3 | 1 | 2 |
| **CO2** | 2 | 2 | 3 | 3 | 2 | 1 | 2 | 2 | 2 | 3 | 1 | 1 |
| **CO3** | 2 | 2 | 3 | 3 | 2 | 1 | 2 | 2 | 2 | 3 | 1 | 3 |
| **CO4** | 2 | 2 | 3 | 3 | 2 | 1 | 2 | 2 | 2 | 3 | 1 | 3 |
| **CO5** | 2 | 2 | 3 | 3 | 2 | 1 | 2 | 2 | 2 | 3 | 1 | 3 |

**Detailed Syllabus:**

1. **Electronic Spectroscopy of Atoms:** Bohr-Sommerfeld model of atomic structure, Electronic wave function and atomic quantum numbers – hydrogen spectrum – orbital, spin and total angular momentum - fine structure of hydrogen atom – many electron spectrum: Lithium atom spectrum, angular momentum of many electrons – term symbols – the spectrum of helium and alkaline earths – equivalent and non-equivalent electrons –X-ray photoelectron spectroscopy. *(Lectures 8)*
2. **Electronic Spectroscopy of Molecules:** Diatomic molecular spectra: Born-Oppenheimer approximation – vibrational spectra and their progressions – Franck-Condon principle – dissociation energy and their products –rotational fine structure of electronic-vibration transition - molecular orbital theory – the spectrum of molecular hydrogen – change of shape on excitation – chemical analysis by electronic spectroscopy – reemission of energy – fundamentals of UV photoelectron spectroscopy. *(Lectures 9)*
3. **Microwave and Raman Spectroscopy:** Rotation of molecules and their spectra – diatomic molecules – intensity of line spectra – the effect of isotropic substitution – non-rigid rotator and their spectra – polyatomic molecules (linear and symmetric top molecules) – Classical theory of Raman effect - pure rotational Raman spectra (linear and symmetric top molecules). *(Lectures 8)*
4. **Infra-red and Raman Spectroscopy:** The energy of diatomic molecules – Simple Harmonic Oscillator - the Anharmonic oscillator– the diatomic vibrating rotator – vibration-rotation spectrum of carbon monoxide –breakdown of Born-Oppenheimer approximation – the vibrations of polyatomic molecules –influence of rotation on the spectra of polyatomic molecules (linear and symmetric top molecules) – Raman activity of vibrations – vibrational Raman spectra – vibrations of Spherical top molecules. *(Lectures 8)*
5. **Spin Resonance Spectroscopy** Spin and magnetic field interaction – Larmor precession – relaxation time – spin-spin relaxation - spin–lattice relaxation - NMR chemical shift - coupling constants – coupling between nuclei – chemical analysis by NMR – NMR for nuclei other than hydrogen – ESR spectroscopy - fine structure in ESR. *(Lectures 8)*

**Text Books:**

1. Fundamentals of Molecular Spectroscopy: Colin N. Banwell and Elaine M. McCash (Tata McGraw-Hill Publishing Company limited).
2. Physics of Atoms and Molecules: B. H. Bransden and C. J. Joachain.

**Reference Books:**

1. Physical method for Chemists (Second Edition):*Russell S. Drago (Saunders College Publishing).*
2. Introduction to Atomic Spectra: *H.E. White-Auckland McGraw Hill, 1924.*
3. Spectroscopy Vol. I, II & III: *Walker & Straughen*
4. Introduction to Molecular spectroscopy: *G.M. Barrow-Tokyo McGraw Hill, 1961.*
5. Spectra of diatomic molecules: *Herzberg-New York, 1944.*

| **MSPH426-18** | **Atomic, Nuclear, and Particle Physics Lab** | **L-3, T-1, P-0** | **4 Credits** |
|---|---|---|---|

**Pre-requisite:** Understanding of graduate level atomic spectroscopy and nuclear physics

**Course Objectives:** The aim and objective of the lab on **Atomic, Nuclear and Particle Physics** is to expose the students of M.Sc. students to experimental techniques in atomic and nuclear physics so that they can verify some of the results obtained in theory and develop confidence to handle sophisticated equipment.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Acquire hands on experience of using particle detectors such as GM counter and Scintillation counter. |
| **CO2** | Handle oscilloscope for visualisation of various input and output signals. |
| **CO3** | Understand the basic of nuclear safely management. |
| **CO4** | Perform scientific experiments as well as accurately record and analyze the results of nuclear experiments. |
| **CO5** | Solve applied nuclear problems with critical thinking and analytical reasoning. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO2** | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 2 |
| **CO3** | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 2 |
| **CO4** | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO5** | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

**Detailed Syllabus:**

**Note: Students are expected to perform atleast 10 experiments out of following list.**

1. Determination of e/m of electron by Normal Zeeman Effect using Febry Perot interferometer.
2. To verify the existence of Bohr's energy levels with Frank-Hertz experiments.
3. Determination of Lande's factor of DPPH using Electron-spin resonance (E.S.R.) spectrometer.
4. Determination of ionization Potential of Lithium.
5. Analysis of pulse height of gamma ray spectra.
6. To study the characteristics of G.M. tube.
7. To verify the inverse square law using GM counter.
8. To determine the dead time of G.M. counter.
9. To study absorption of beta particles is matter using GM counter.
10. To study Gaussian distribution using G.M. counter.
11. To estimate the efficiency of GM detector for Gamma and Beta source.
12. Determination of Planck's constant using Photocell and interference filters.
13. Verification of Inverse square law using Photocell.
14. To study Gaussian distribution using scintillation counter.
15. To study absorption of gamma radiation by scintillation counter.
16. To estimate the efficiency of Scintillator counter.

**Text Books:**

1. Fundamentals of Molecular Spectroscopy: *Colin N. Banwell and Elaine M. McCash (Tata McGraw-Hill Publishing Company limited).*
2. Physics of Atoms and Molecules: *B. H. Bransden and C. J. Joachain.*

**Reference Books:**

1. Physical method for Chemists (Second Edition): *Russell S. Drago (Saunders College Publishing).*
2. Introduction to Atomic Spectra: *H.E. White-Auckland McGraw Hill, 1924.*
3. Spectroscopy Vol. I, II & III: *Walker & Straughen*
4. Introduction to Molecular spectroscopy: *G.M. Barrow-Tokyo McGraw Hill, 1961.*
5. Spectra of diatomic molecules: *Herzberg-New York, 1944.*

| **MSPH427-18** | **Computational Physics Lab-II** | **L-3, T-1, P-0** | **4 Credits** |
|---|---|---|---|

**Pre-requisite:** Understanding of graduate level numerical methods and C++

**Course Objectives:** The aim and objective of the lab on **Computational Physics-II** is to train the students of M.Sc. class in understanding numerical methods, the usage of high level language such as C++ language for simulation of results for different physics problems and graphic analysis of physical data, so that they are well equipped in the use of computer for solving physics related problems.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| CO1 | Understand and apply basics knowledge of numerical methods in solving the physics problems. |
| CO2 | Write programme with the C++ or any other high level language. |
| CO3 | Learn use of graphical methods in data analysis and solving physics problems. |
| CO4 | Solve physical problem enabling development of critical thinking and analytical reasoning. |
| CO5 | Apply computational physics in frontier areas of pure and applied research in physics and allied fields |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 3 | 2 | 3 | 2 |
| **CO2** | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO3** | 1 | 2 | 1 | 3 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| **CO4** | 3 | 3 | 2 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **CO5** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 | 1 |

**Detailed Syllabus:**

1. Write a program to study graphically the EM oscillations in a LCR circuit (use Runge-Kutta Method). Show the variation of (i) Charge vs Time and (ii) Current vs Time.
2. Study graphically the motion of falling spherical body under various effects of medium (viscous drag, buoyancy and air drag) using Euler method.
3. Study graphically the path of a projectile with and without air drag using FN method. Find the horizontal and maximum height in either case. Write your comments on the findings.
4. Study the motion of an artificial satellite.
5. Study the motion of (a) 1-D harmonic oscillator (without and with damping effects).(b) two coupled harmonic oscillators. Draw graphs showing the relations: i) Velocity vs Time, ii) Acceleration vs Time iii) Position vs Time, also compare the numerical and analytical results.
6. To obtain the energy eigenvalues of a quantum oscillator using the Runge-Kutta method.
7. Study the motion of a charged particle in: (a) Uniform electric field, (b) Uniform Magnetic field, (c) in combined uniform electric and magnetic fields. Draw graphs in each case.
8. Use Monte Carlo techniques to simulate phenomenon of (i) Nuclear Radioactivity. Do the cases in which the daughter nuclei are also unstable with half life greater/lesser than the parent nucleus. (ii) to determine solid angle in a given geometry. (iii) simulate attenuation of gamma rays/neutron in an absorber and (iv) solve multiple integrals and compare results with Simpson's method.
9. To study phase trajectory of a Chaotic Pendulum.
10. To study convection in fluids using Lorenz system.

**Text Books:**

1. Numerical Recipes in C++ The Art of Scientific Computing. William H. Press, Saul, A.Teukolsky, William T. Vetterling, and Brian P. Flannery, (Cambridge), 1nd ed. 2001.
2. A First Course in Computational Physics: P.L. DeVries (John Wiley) 2000.

**Reference Books:**

1. An introduction to Computational Physics: Tao Pang (Cambridge), 1nd ed. 2006.
2. Computer Applications in Physics: S. Chandra (Narosa), 2006.
3. Computational Physics: R.C. Verma, P.K. Ahluwalia and K.C. Sharma (New Age), 2005.
4. Object Oriented Programming with C++: Balagurusamy, (Tata McGrawHill), 5th ed. 2011.

| MSPH531-18 | Condensed Matter Physics | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** Understanding of graduate level solid state physics

**Course Objectives:** The aim and objective of the course on **Condensed Matter Physics** is to expose the students of M.Sc. class to the topics like elastic constants, lattice vibrations, dielectric properties, energy band theory and transport theory so that they are equipped with the techniques used in investigating these aspects of the matter in condensed phase.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Gain in-depth knowledge about the formation of various crystal structure via performing calculations on their elemental parameters. |
| **CO2** | Differentiate between various lattice types based on their lattice dynamics and then explain thermal properties of crystalline solids. |
| **CO3** | Understand the electron motion in periodic solids and origin of energy bands in semiconductors. |
| **CO4** | To explain the basic transport theory for understanding the transport phenomenon in solids |
| **CO5** | Using various models of molecular polarizability, understand the dielectric properties of insulators. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 1 | 2 |
| **CO2** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO3** | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 1 | 2 |
| **CO4** | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO5** | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 |

**Detailed Syllabus:**

1. **Crystal binding and Elastic constants:** Binding in solids; Cohesive energy, Crystals of Inert gases, ionic crystal, Covalent Crystals, Analysis of elastic strains: dilation, stress components; Elastic Compliance and Stiffness: elastic constants, elastic waves in cubic crystals. (Lectures 6)
2. **Lattice Dynamics and Thermal Properties:** Vibrations of crystal with monatomic and two atom per primitive Basis; Quantization of Elastic waves, Phonon momentum; Inelastic scattering by phonons, Phonon Heat Capacity, Planck Distribution, normal modes; Density of states, Debye T2 model; Einstein Model; anharmonic crystal interactions; thermal conductivity expansion. (Lectures 9)
3. **Energy Band Theory:** Electrons in a periodic potential: Bloch theorem, Nearly free electron model; Kronig Penney Model; Electron in a periodic potential; tight binding method; Wigner-Seitz Method Semiconductor Crystals, Band theory of pure and doped semiconductors; effective mass elementary idea of semiconductor superlattices. (Lectures 9)
4. **Transport Theory:** Electronic transport from classical kinetic theory; Introduction to Boltzmann transport equation; electrical and thermal conductivity of metals; thermoelectric effects; Hall effect and magneto resistance. (Lectures 8)
5. **Dielectrics and Ferro Electrics:** Polarization mechanisms, Dielectric function from oscillator strength, Clausius-Mosotti relation; piezo, pyro- and ferro-electricity; Dipole theory of ferroelectricity; thermodynamics of ferroelectric transition. (Lectures 8)

**Text Books:**

1. Introduction to Solid State Physics: *C. Kittel (Wiley, New York), 8th ed. 2005.*
2. Quantum Theory of Solids: *C. Kittel (Wiley, New York) 1987.*

**Reference Books:**

1. Principles of the Theory of Solids: *J. Ziman (Cambridge University Press) 1971*
2. Solid State Theory: *Walter A. Harrison (Tata McGraw-Hill, New Delhi) 1970.*
3. Liquid Crystals: *S. Chandrasekhar (Cambridge University), 1nd ed. 1991.*

| MSPH532-18 | Nuclear Physics | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** Understanding of graduate level physics

**Course Objectives:** The aim and objective of the course on **Nuclear Physics** is to familiarize the students of M.Sc. class to the basic aspects of Nuclear Physics like static properties of nuclei, radioactive decays, nuclear forces, nuclear models, and nuclear reactions so that they are equipped with the techniques used in studying these things.

**Course Outcomes:** At the end of the course the student will be able to

| | |
|---|---|
| **CO1** | Understand and compare nuclear models and explain nuclear properties using nuclear models. |
| **CO2** | Understand structure and static properties of nuclei. |
| **CO3** | Analyse various decay mode of nucleus. |
| **CO4** | Use nucleon-nucleon scattering and deuteron problem to explain nature of nuclear forces. |
| **CO5** | Describe various types of nuclear reactions and their properties. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO2** | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO3** | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO4** | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO5** | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |

**Detailed Syllabus:**

1. **Nuclear Models:** Liquid drop model, Binding energy; fission and fusion, Experimental evidence for shell effects, Shell Model, Spin-Orbit coupling, Magic numbers, Application of Shell Model like Angular momenta and parities of nuclear ground states, Collective model-nuclear vibrations spectra and rotational spectra. *(Lectures 8)*

2. **Static properties of nucleus:** Nuclear radii and measurements, nuclear binding energy (review), nuclear moments and systematic, wave-mechanical properties of nuclei, hyperfine structure. *(Lectures 5)*

3. **Nuclear decay:** Review of barrier penetration of alpha decay & Geiger-Nuttal law. Beta decays, Fermi theory, Kurie plots and comparative half-lives, Allowed and forbidden transitions, Experimental evidence for Parity-violation in beta decay, Electron capture probabilities, Neutrino, detection of neutrinos, Multipolarity of gamma transitions, internal conversion process. *(Lectures 10)*

4. **Nuclear forces:** Evidence for saturation of nuclear density and binding energies (review), types of nuclear potential, Ground and excited states of deuteron, dipole and quadrupole moment of deuteron, single and triplet potentials, meson theory of nuclear forces. *(Lectures 10)*

5. **Nuclear reactions:** Nuclear reactions and cross-sections, Resonance, Breit- Wigner dispersion formula for l=0 and higher values, compound nucleus, Direct reactions, Transfer reactions. *(Lectures 7)*

**Text Books:**

1. Nuclear Physics*: Irving Kaplan (Narosa), 2001.*
2. Theory of Nuclear Structure: *R.R. Roy and B.P. Nigam (New Age, New Delhi) 2005.*

**Reference Books:**

1. Basic Ideas and Concepts in Nuclear Physics *: K. Hyde (Institute of Physics) 2004.*
2. Nuclear physics: Experimental and Theoretical, *H.S. Hans (New Academic Science) 1nd ed (2011).*
3. Nuclear Physics and its applications: *John Lile*
4. Nuclear Physics: *V. Devnathan*

| MSPH533-18 | Particle Physics | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** course on Quantum mechanics and Quantum field Theory

The aim and objective of the course on **Particle Physics** is to introduce the M.Sc. students to the invariance principles and conservation laws, hadron-hadron interactions, relativistic kinematics, static quark model of hadrons and weak interactions so that they grasp the basics of fundamental particles in proper perspective.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Overview the particle spectrum, their interaction and major historical and latest developments. |
| **CO2** | Understand the implications of various invariance principles and symmetry properties in particle physics. |
| **CO3** | Master relativistic kinematics for computations of outcome of various reactions and decay processes |
| **CO4** | Properties of baryons and mesons in terms of naive nonrelativistic quark model. |
| **CO5** | Weak interaction in quarks and leptons and how that this is responsible for $\beta$ decay. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 1 | 3 |
| **CO2** | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| **CO3** | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | - | 1 |
| **CO4** | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO5** | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 1 | 3 | 2 | - | 2 |

**Detailed Syllabus:**

1. **Introduction:** Fermions and bosons, particles and antiparticles, quarks and leptons, interactions and fields in particle physics, classical and quantum pictures, Yukawa picture, types of interactions - electromagnetic, weak, strong and gravitational, units. *(Lectures 7)*
2. **Invariance Principles and Conservation Laws:** Invariance in classical mechanics and quantum mechanics, Parity, Pion parity, Charge conjugation, Positronium decay, Time reversal invariance, CPT theorem. *(Lectures 7)*
3. **Hadron-Hadron Interactions:** Cross section and decay rates, Pion spin, Isospin, Two nucleon system, Pion-nucleon system, Strangeness and Isospin, G-parity, Total and Elastic cross section, Particle production at high energy. *(Lectures 7)*
4. **Relativistic Kinematics and Phase Space:** Introduction to relativistic kinematics, particle reactions, Lorentz invariant phase space, two-body and three-body phase space, dalitz plots, K-2p-decay, t-θ puzzle, dalitz plots for dissimilar particles, Breit-Wigner resonance formula, Mandelstem variables. *(Lectures 7)*
5. **Static Quark Model of Hadrons:** The Baryon decuplet, quark spin and color, baryon octer, quark-antiquark combination. *(Lectures 7)*
6. **Weak Interactions:** Classification of weak interactions, Fermi theory, Parity non conservation in ß-decay, experimental determination of parity violation, helicity of neutrino, K-decay, CP violation in K- decay and its experimental determination. *(Lectures 7)*

**Text Books:**

1. Introduction to High Energy Physics: D.H. Perkins (Cambridge University Press), 2000.
2. Gauge Theory of Elementary Particle Physics: T.P Cheng & L.F. Li (Oxford).
3. An Introductory Course of Particle Physics: Palash Pal (CRC Press).

**Reference Books:**

1. Elementary Particles : I.S. Hughes (Cambridge University Press), 2rded. 1991.
2. Introduction to Quarks and Partons : F.E. CLose (Academic Press, London), 1979.
3. Introduction to Particle Physics : M.P. Khanna (Prentice Hall of India, New Delhi), 2004.
4. Dynamics of the Standard Model: J.F. Donoghue (Cambridge University Press).
5. First Book of Quantum Field Theory: A. Lahiri & P. Pal, Narosa, New Delhi.
6. Introduction to Quantum Field Theory: M. Peskin & D.V. Schroeder. (Levant Books).

## Elective Subject -I

| **MSPH534-18** | **Fibre Optics and Non-linear optics** | L-3, T-1, P-0 | **4 Credits** |
|---|---|---|---|

**Pre-requisite:** Understanding of graduate level optics

**Course Objectives: Course Objectives:** The aim and objective of the course on **Fibre Optics and Nonlinear Optics** is to expose the M.Sc. students to the basics of the challenging research field of optical fibres and their use in nonlinear optics.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Understand the structure of optical fiber and describe properties of optical fibers. |
| **CO2** | Identify and compare the various processes of fibers fabrication |
| **CO3** | Describe the optics of anisotropic media |
| **CO4** | Analyze the electro-optic and acousto-optic effects in fibers |
| **CO5** | analyze non-linear effects in optical fibers. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | - | 1 | - | 1 | - | 1 | - | 3 | - | 1 |
| **CO2** | 3 | 2 | 1 | 1 | 1 | 1 | - | 1 | - | 3 | - | 1 |
| **CO3** | 2 | 2 | - | 1 | - | 1 | - | 1 | - | 3 | - | 1 |
| **CO4** | 3 | 2 | 1 | 1 | 1 | - | - | 1 | - | 3 | - | 1 |
| **CO5** | 3 | 2 | 1 | 1 | 1 | - | - | 1 | - | 3 | - | 1 |

**Detailed Syllabus:**

1. **Optical fibre and its properties:** Introduction, basic fibre construction, propagation of light, modes and the fibre, refractive index profile, types of fibre, dispersion, data rate and band width, attenuation, leaky modes, bending losses, cut-off wavelength, mode field diameter, other fibre types. *(Lectures 7)*

2. **Fiber fabrication and cable design:** Fibre fabrication, mass production of fiber, comparison of the processes, fiber drawing process, coatings, cable design requirements, typical cable design, testing. *(Lectures 5)*

3. **Optics of anisotropic media:** Introduction, the dielectric tensor, stored electromagnetic energy in anisotropic media, propagation of monochromatic plane waves in anisotropic media, directions of D for a given wave vector, angular relationships between D, E, H, k and Poynting vector S, the indicatrix, uniaxial crystals, index surfaces, other surfaces related to the uniaxial indicatrix, Huygenian constructions, retardation, biaxial crystals, intensity through polarizer/waveplate/ polarizer combinations. *(Lectures 10)*

4. **Electro-optic and acousto-otpic effects and modulation of light beams**: Introduction to the electro-optic effects, linear electro-optic effect, quadratic electro-optic effects, longitudinal electro-optic modulation, transverse electro optic modulation, electro optic amplitude modulation, electro-optic phase modulation, high frequency wave guide, electro-optic modulator, strain optic tensor, calculation of LM for a logitudinal acoustic wave in isotropic medium, Raman-Nath diffraction, Raman-Nath acousto-optic modulator. *(Lectures 10)*

5. **Non-linear optics/processes**: Introduction, anharmonic potentials and nonlinear polarization, non-linear susceptibilities and mixing coefficients, parametric and other nonlinear processes, macroscopic and microscopic susceptibilities. *(Lectures 8)*

**Text Books:**

1. The Elements of Fibre Optics: *S.L.Wymer and Meardon (Regents/Prentice Hall), 1992.*

**Reference Books:**

1. Lasers and Electro-Optics: *C.C. Davis (Cambridge University Press), 1996.*
2. Optical Electronics: *Gathak & Thyagarajan (Cambridge Univ. Press), 1989.*
3. The Elements of Non-linear Optics: *P.N. Butcher & D. Cotter (Cambridge University Press), 1991.*

Elective Subject -I

| MSPH535-18 | Radiation Physics | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** Understanding of graduate level nuclear physics

**Course Objectives:** The aim and objective of the course on **Radiation Physics** is to expose the students of M.Sc. class to the relatively advanced topics Radiation Physics and nuclear reactions so that they understand the details of the underlying aspects and can use the techniques if they decide to be radiation or nuclear physicists in their career.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Understand various modes of interaction of electromagnetic radiations and charged particles with matter. |
| **CO2** | Distinguish various types of radiations based on their interaction with matter. |
| **CO3** | Learn and understand about different detectors and their use for spectroscopy. |
| **CO4** | Use different analytical technique such as XRF, PIXE, neutron activation analysis and electron spin resonance spectroscopy. |
| **CO5** | Design experiments to analyze effects of radiation on various objects. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 1 | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 |
| **CO2** | 1 | 1 | 1 | - | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| **CO3** | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO4** | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| **CO5** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |

**Detailed Syllabus:**

1. **Interaction of electromagnetic radiations with Matter:** Different photon interaction processes viz. photoelectric effect, Compton scattering and pair production. Minor interaction processes, Energy and Z dependence of partial photon interaction processes. Attenuation coefficients, Broad and narrow beam geometries. Multiple scattering.
*(Lectures 8)*

2. **Interaction of charged particles with Matter:** Elastic and inelastic collisions with electrons and atomic nucleus. Energy loss of heavy charged particles. Range-energy relationships, Straggling. Radiative collisions of electrons with atomic nucleus.
*(Lectures 8)*

3. **Nuclear Detectors and Spectroscopy:** General characteristics of detectors, Gas filled detectors, Organic and inorganic scintillation detectors, Semi-conductor detectors [Si(Li), Ge(Li) HPGe]. Room temperature detectors, Gamma ray spectrometers. Gamma ray spectrometry with NaI(Tl) scintillation and semiconductor detectors.
*(Lectures 8)*

4. **Nuclear spectrometry and applications:** Analysis of nuclear spectrometric data, Measurements of nuclear energy levels, spins, parities, moments, internal conversion coefficients, Angular correlation, Perturbed angular correlation, Measurement of g-factors and hyperfine fields.
*(Lectures 8)*

5. **Analytical Techniques:** Principle, instrumentation and spectrum analysis of XRF, PIXE and neutron activation analysis (NAA) techniques. Theory, instrumentation and applications of electron spin resonance spectroscopy (ESR). Experimental techniques and applications of Mossbauer effect, Rutherford backscattering. Applications of elemental analysis, Diagnostic nuclear medicine, Therapeutic nuclear medicine.
*(Lectures 8)*

**Text Books:**

1. The Atomic Nucleus: R.D. Evans, Tata Mc Graw Hill, New Delhi.
2. Nuclear Radiation Detectors: S. S. Kapoor and V. S. Ramamurthy, New Age, International, New Delhi.

**Reference Books:**

1. Radiation Detection and Measurements: G. F. Knoll, Wiley & Sons, New Delhi.
2. Introductory Nuclear Physics: K. S. Krane, Wiley & Sons, New Delhi.
3. An Introduction to X-ray Spectrometry: Ron Jenkin, Wiley.
4. Techniques for Nuclear and Particle Physics Experiments: W. R. Leo, Narosa Publishing House, New Delhi.
5. Introduction to experimental Nuclear Physics: R.M. Singru, Wiley & Sons, New Delhi.

**Elective Subject -I**

| **MSPH536-18** | **Nonlinear Dynamics** | **L-3, T-1, P-0** | **4 Credits** |
|---|---|---|---|

**Pre-requisite:** Understanding of graduate level physics

**Course Objectives:** The aim and objective of the course on **Nonlinear Dynamics** is to familiarize the M.Sc. students with the basics of the recently emerging research field of dynamics of nonlinear Hamiltonian systems.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Understand basic knowledge of nonlinear dynamics and phenomenology of chaos. |
| **CO2** | Apply the tools of dynamical systems theory in context to models. |
| **CO3** | Learn skills by solving problems on solving nonlinear problems using numerical methods. |
| **CO4** | Understand Hamilton approach for describing various physical system. |
| **CO5** | Quantify classical chaos and Quantum chaos. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | 1 | - | 1 | 2 | 1 | 2 | 2 | 2 | 2 |
| **CO2** | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| **CO3** | 3 | 2 | - | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| **CO4** | 2 | 2 | - | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| **CO5** | 2 | 2 | - | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |

**Detailed Syllabus:**

1. **Phenomenology of Chaos**: Linear and nonlinear systems, A nonlinear electrical system, Biological population growth model, Lorenz model; determinism, unpredictability and divergence of trajectories, Feigenbaum numbers and size scaling, self similarity, models and universality of chaos. *(Lectures 8)*

2. **Dynamics in State Space:** State space, autonomous and nonautonomous systems, dissipative systems, one dimensional state space, Linearization near fixed points, two dimensional state space, dissipation and divergence theorem. Limit cycles and their stability, Bifurcation theory, Heuristics, Routes to chaos. Three-dimensional dynamical systems, fixed points and limit cycles in three dimensions, Lyapunov exponents and chaos. Three dimensional iterated maps, U-sequence. *(Lectures 10)*

3. **Hamiltonian System**: Non-integrable systems, KAM theorem and period doubling, standard map. Applications of Hamiltonian Dynamics, chaos and stochasticity. *(Lectures 8)*

4. **Quantifying Chaos**: Time series, Lyapunov exponents. Invariant measure, Kolmogorov - Sinai entropy. Fractal dimension, Statistical mechanics and thermodynamic formalism. *(Lectures 7)*

5. **Quantum Chaos**: Quantum Mechanical analogies of chaotic behaviour, Distribution of energy eigenvalue spacing, chaos and semi-classical approach to quantum mechanics. *(Lectures 7)*

**Text Books:**

1. Chaos and Non Linear Dynamics: R.C. Hilborn (Oxford Univ. Press), 2001.

**Reference Books:**

1. Chaos in Dynamical Systems: E. Ott (Cambridge Univ. Press), 2001.
2. Applied Nonlinear Dynamics: A.H. Nayfeh and B. Balachandran (Wiley), 1995.
3. Chaos in Classical and Quantum Mechanics: M.C. Gutzwiller (Springer-Verlag), 1990.

## Elective Subject -II

| MSPH537-18 | Plasma Physics | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** Course on Electrodynamics

**Course Objectives:** The aim and objective of the course on **Plasma Physics** is to expose the M.Sc. students to the basics of the challenging research field Plasma physics.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Understand the origin of plasma, conditions of plasma formation and properties of plasma. |
| **CO2** | Distinguish between the single particle approach, fluid approach and kinetic statistical approach to describe different plasma phenomena. |
| **CO3** | Classify propagation of electrostatic and electromagnetic waves in magnetized and non-magnetized plasmas |
| **CO4** | Describe the basic transport phenomena such as plasma resistivity, diffusion and mobility for both magnetized and non-magnetized plasmas. |
| **CO5** | Formulate the conditions for describing a plasma to be in a state of thermodynamic equilibrium, or non-equilibrium, and analyze the stability of this equilibrium. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 1 | 1 | 1 | - | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 2 |
| **CO2** | 1 | 1 | 1 | - | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 2 |
| **CO3** | 1 | 1 | 1 | - | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 2 |
| **CO4** | 1 | 1 | 1 | - | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 2 |
| **CO5** | 1 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 2 |

**Detailed Syllabus:**

1. **Introduction:** Plasma State, elementary concepts and definitions of temperature and other parameters, occurrence and importance of plasma for various applications, Production of Plasma in the laboratory, Physics of glow discharge, electron emission, ionization, breakdown of gases, Paschen's laws and different regimes of E/p in a discharge, Townsend discharge and the evolution of discharge. *(Lectures 8)*

2. **Plasma diagnostics:** Probes, energy analyzers, magnetic probes and optical diagnostics, preliminary concepts. *(Lectures 5)*

3. **Single particle orbit theory:** Drifts of charged particles under the effect of different combinations of electric and magnetic fields, Crossed electric and magnetic fields, Homogenous electric and magnetic fields, spatially varying electric and magnetic fields, time varying electric and magnetic fields, particle motion in large amplitude waves. *(Lectures 8)*

4. **Fluid description of plasmas:** distribution functions and Liouville's equation, macroscopic parameters of plasma, two and one fluid equations for plasma, MHD approximations commonly used in one fluid equations and simplified one fluid and MHD equations. dielectric constant of field free plasma, plasma oscillations, space charge waves of warm plasma, dielectric constant of a cold magnetized plasma, ion- acoustic waves, Alfven waves, Magnetosonic waves. *(Lectures 10)*

5. **Stability of fluid plasma:** The equilibrium of plasma, plasma instabilities, stability analysis, two stream instability, instability of Alfven waves, plasma supported against gravity by magnetic field, energy principle. microscopic equations for my body system: Statistical equations for many body systems, Vlasov equation and its properties, drift kinetic equation and its properties. *(Lectures 7)*

**Text Books:**

1. Introduction to Plasma Physics, *F.F. Chen*

**Reference Books:**

1. Principles of Plasma Physics, *Krall and Trievelpice*
2. Introduction to Plasma Theory, *D.R. Nicholson*
3. The Plasma State, *J.L. Shohet*
4. Introduction to Plasma Physics, *M. Uman*
5. Principles of Plasma Diagnostic, *I.H. Hutchinson*

**Elective Subject-II**

| **MSPH538-18** | **Structures, Spectra and Properties of Biomolecules** | **L-3, T-1, P-0** | **4 Credits** |
|---|---|---|---|

**Pre-requisite:** Understanding of graduate level chemistry and physics

**Course Objectives:** The aim and objective of the course on **Structures, Spectra and properties of Biomolecules** is to familiarize the M.Sc. students with the basics of the recently emerging research field of dynamics of Structures, Spectra and properties of Biomolecules.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Describe various structural and chemical bonding aspects of Biomolecules. |
| **CO2** | Understand structure and theoretical techniques and their application to Biomolecules. |
| **CO3** | Understand use of various spectroscopic techniques and their application to the Biomolecules. |
| **CO4** | Understand the structure-Function relationship and modeling of biomolecules. |
| **CO5** | Outline and correlate for providing solution to interdisciplinary problem. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 1 | 2 |
| **CO2** | 2 | 2 | 1 | 2 | 2 | 2 | 2 | - | 2 | 2 | 1 | 2 |
| **CO3** | 2 | 2 | 1 | 2 | 1 | 2 | 2 | - | 2 | 2 | 1 | 2 |
| **CO4** | 2 | 2 | 1 | 2 | 2 | 2 | 2 | - | 2 | 2 | 1 | 2 |
| **CO5** | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 1 | 2 |

**Detailed Syllabus:**

1. **Structure Aspects of Biomolecule:** Conformational Principles, Conformation and Configuration Isomers and Derivatives, Structure of Polynucleotides, Structure of Polypeptides, Primary, Secondary, Tertiary and Quaternary Structure of Proteins, Structure of Polysaccharides. *(Lectures10)*

2. **Theoretical Techniques and Their Application to Biomolecules:** Hard Sphere Approximation, Ramachandran Plot, Potential Energy Surface, Outline of Molecular Mechanics Method, Brief ideas about Semi-empirical and Ab initio Quantum Theoretical Methods, Molecular Charge Distribution, Molecular Electrostatic Potential and Field and their uses. *(Lectures 10)*

3. **Spectroscopic Techniques and their Application to Biomolecules:** Use of NMR in Elucidation of Molecular Structure, Absorption and Fluorescence Spectroscopy, Circular Dichroism, Laser Raman Spectroscopy, IR spectroscopy, Photoacoustic Spectroscopy, Photo-biological Aspects of Nucleic Acids. *(Lectures 10)*

4. **Structure-Function Relationship and Modeling:** Molecular Recognition, Hydrogen Bonding, Lipophilic Pockets on Receptors, Drugs and Their Principles of Action, Lock and Key Model and Induced fit Model. *(Lectures 10)*

**Text Books:**

1. *Srinivasan & Pattabhi:* Structure Aspects of Biomolecules.

**Reference Books:**

1. *Govil & Hosur*: Conformations of Biological Molecules
2. *Price:* Basic Molecular Biology
3. *Pullman:* Quantum Mechanics of Molecular Conformations
4. *Lehninger:* Biochemistry
5. Mehler & Cordes: Biological Chemistry
6. *Smith and Hanawait:* molecular Photobiology, Inactivation and Recovery

**Elective Subject - II**

| **MSPH539-18** | **Science of Renewable source of Energy** | **L-3, T-1, P-0** | **4 Credits** |
|---|---|---|---|

**Pre-requisite:** Understanding of graduate level semiconductor physics

**Course Objectives:** The aim and objective of the course on **Science of renewable Energy Sources** is to expose the M.Sc. students to the basics of the alternative energy sources like solar energy, hydrogen energy, etc.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| CO1 | Understand the energy demand of world & distinguish between traditional and alternative form of energy. |
| CO2 | Describe the concept of solar energy radiation and thermal applications. |
| CO3 | Analyze making of solar cell and its types. |
| CO4 | Identify hydrogen as energy source, its storage and transportation methods. |
| CO5 | Compare wind energy, wave energy and ocean thermal energy conversion. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | 1 | - | 1 | 2 | 1 | 2 | 3 | 2 | 2 |
| **CO2** | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 |
| **CO3** | 3 | 2 | - | 2 | 1 | 1 | 2 | 1 | 1 | 3 | 1 | 1 |
| **CO4** | 2 | 2 | - | 2 | 1 | 1 | 2 | 1 | 1 | 3 | 1 | 1 |
| **CO5** | 2 | 2 | - | 2 | 1 | 1 | 2 | 1 | 1 | 3 | 1 | 1 |

**Detailed Syllabus:**

1. **Introduction**: Production and reserves of energy sources in the world and in India, need for alternatives, renewable energy sources. *(Lectures 8)*

2. **Solar Energy**: Thermal applications, solar radiation outside the earth's atmosphere and at the earth's surface, Principal of working of solar cell, Performance characteristics of solar cell. Types of solar cell, crystalline silicon solar cell, Thin film solar cell, multijunction solar cell, Elementary ideas of perovskite solar cell, dye synthesized solar cell and Tandem solar cell, PV solar cell, module, array, and panel, Applications. *(Lectures 11)*

3. **Hydrogen Energy**: Environmental considerations, solar hydrogen through photo electrolysis and photocatalytic process, physics of material characteristics for production of solar hydrogen. Storage processes, solid state hydrogen storage materials, structural and electronic properties of storage materials, new storage modes, safety factors, use of hydrogen as fuel; use in vehicles and electric generation, fuel cells. *(Lectures 10)*

4. **Other sources**: Nature of wind, classification and descriptions of wind machines, power coefficient, energy in the wind, wave energy, ocean thermal energy conversion (OTEC), system designs for OTEC, basic idea about biogas, biofuel, and biodiesel. *(Lectures 8)*

**Text Books:**

1. Solar Energy: *S.P. Sukhatme (Tata McGraw-Hill, New Delhi), 2008.*

**Reference Books:**

1. Solar Cell Devices: *Fonash (Academic Press, New York),2010.*
2. Fundamentals of Solar Cells, Photovoltaic Solar Energy: *Fahrenbruch and Bube (Springer, Berlin), 1982.*
3. Photoelectrochemical Solar Cells : *Chandra (New Age,New Delhi).*

| MSPH540-18 | Condensed Matter Physics Lab | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** Understanding of graduate level solid state physics experiments

**Course Objectives:** The aim and objective of the courses on **Condensed Matter Physics Lab** is to train the students of M.Sc. class to advanced experimental techniques in condensed matter physics so that they can investigate various relevant aspects and are confident to handle sophisticated equipment and analyze the data.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| CO1 | Measure conductivity, resistivity and thermo-dynamical properties of solids. |
| CO2 | Measure magnetic properties and magnetic behavior of magnetic materials. |
| CO3 | Describe the lattice dynamics of simple lattice structures in terms of dispersion relations. |
| CO4 | Design and carry out scientific experiments as well as accurately record and analyze the results of experiments. |
| CO5 | Solve problem with critical thinking and analytical reasoning. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | 1 | 1 | 1 | - | - | 2 | 2 | 2 | 2 | 2 |
| CO2 | 2 | 1 | 1 | 1 | 1 | - | - | 2 | 2 | 2 | 2 | 2 |
| CO3 | 1 | 1 | 1 | 1 | 1 | - | - | 2 | 2 | 2 | 2 | 2 |
| CO4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| CO5 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

**Detailed Syllabus:**

**Note: Students are expected to perform atleast ten experiments out of following list.**

1. To study temperature dependence of conductivity of a given semiconductor crystal using four probe method.
2. Verification of curie-weiss law for the electrical susceptibility of a ferroelectric material.
3. To determine charge carrier density and Hall coefficient by Hall effect.
4. To determine magnetic susceptibility of material using Quink 's tube method.
5. To determine energy gap and resistivity of the semiconductor using four probe method.
6. To study the B-H loop characteristics.
7. To determine dielectric constant of a material with Microwave set up.
8. To measure the Curie temperature of a given PZT sample.
9. To measure the velocity of ultrasonic wave in liquids.
10. To study dispersion relation for Mono-atomic and Diatomic lattices using Lattice dynamic kit.
11. To study the properties of crystals using X-Ray Apparatus.

**Text Books:**

1. Introduction to Solid State Physics: *C. Kittel (Wiley, New York), 8th ed. 2005.*
2. Quantum Theory of Solids: *C. Kittel (Wiley, New York) 1987.*

**Reference Books:**

1. Principles of the Theory of Solids: *J. Ziman (Cambridge University Press) 1971*
2. Solid State Theory: *Walter A. Harrison (Tata McGraw-Hill, New Delhi) 1970.*
3. Liquid Crystals: *S. Chandrasekhar (Cambridge University), 1nd ed. 1991.*

## Elective Subject -III

| MSPH541-18 | Physics of Nanomaterials | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite: Condensed matter physics**

**Course Objectives:** The aim and objective of the course on **Physics of Nano-materials** is to familiarize the students of M.Sc. to the various aspects related to preparation, characterization and study of different properties of nanomaterials so that they can pursue this emerging research field as career.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Apply the knowledge on free electron theory to the band structure of metals, insulators, and semiconductors. |
| **CO2** | Acquire knowledge of basic approaches to synthesize the inorganic nanoparticles |
| **CO3** | Describe the use of unique optical properties of nanoscale metallic structures for analytical and biological applications |
| **CO4** | Understand the physical and chemical properties of carbon nanotubes and nanostructured mesoporous materials. |
| **CO5** | Determine the structure-property relationships in nanomaterials as well as the concepts, not applicable at larger length scales. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 1 | 2 | 2 | 3 | 3 | 1 | 2 | 1 | 1 | 2 | 2 | 3 |
| **CO2** | 1 | 2 | 2 | 3 | 3 | 2 | 2 | 1 | 1 | 2 | 2 | 3 |
| **CO3** | 1 | 2 | 2 | 3 | 3 | 2 | 2 | 1 | 1 | 2 | 2 | 3 |
| **CO4** | 1 | 2 | 2 | 3 | 3 | 2 | 2 | 1 | 1 | 2 | 2 | 3 |
| **CO5** | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 3 |

**Detailed Syllabus:**

1. **Introductory Aspects:** Free electron theory and its features, Idea of band structure - metals, insulators and semiconductors. Density of state in one, two, and three dimensional bands and its variation with energy, Effect of crystal size on density of states and band gap. Examples of nanomaterials. *(Lectures 8)*

2. **Preparation of Nanomaterials:** Bottom up: Cluster beam evaporation, ion beam deposition, chemical bath deposition with capping techniques and Top down: Ball Milling. *(Lectures 8)*

3. **General Characterization Techniques:** Determination of particle size, study of texture and microstructure, Increase in x-ray diffraction peaks of nanoparticles, shift in photo luminescence peaks, variation in Raman spectra of nanomaterials, photoemission microscopy, scanning force microscopy. *(Lectures 8)*

4. **Quantum Dots:** Electron confinement in infinitely deep square well, confinement in one and two-dimensional wells, idea of quantum well structure, Examples of quantum dots, spectroscopy of quantum dots. *(Lectures 8)*

5. **Other Nanomaterials:** Properties and applications of carbon nanotubes and nanofibres, Nanosized metal particles, Nanostructured polymers, Nanostructured films and Nano structured semiconductors. *(Lectures 8)*

**Text Books:**

1. Nanotechnology-Molecularly Designed Materials: *G.M. Chow & K.E. Gonsalves (American Chemical Society), 1996.*
2. Nanotechnology Molecular Speculations on Global Abundance: *B.C. Crandall (MIT Press), 1996.*

**Reference Books:**

1. Quantum Dot Heterostructures: *D. Bimerg, M. Grundmann and N.N. Ledentsov (Wiley), 1998.*
2. Nanoparticles and Nanostructured Films–Preparation, Characterization and Application: *J.H.Fendler (Wiley), 1998.*
3. Nanofabrication and Bio-system: *H.C. Hoch, H.G. Craighead and L. Jelinski (Cambridge Univ. Press), 1996.*
4. Physics of Semiconductor Nanostructures: *K.P. Jain (Narosa), 1997.*
5. Physics of Low-Dimension Semiconductors: *J.H. Davies (Cambridge Univ. Press) 1998.*
6. Advances in Solid State Physics (Vo.41): *B. Kramer (Ed.) (Springer), 2001.*

**Elective Subject -III**

| MSPH542-18 | Experimental Techniques in Nuclear and Particle Physics | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** Course on Nuclear Physics and Particle Physics

**Course Objectives:** The aim and objective of the course on **Experimental Techniques in Nuclear and Particle Physics** is to expose the students of M.Sc. students to experimental aspects of different equipment and methods used in the fields of nuclear physics and particle physics.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| CO1 | Understand various experimental techniques for describing interaction of radiations with matter. |
| CO2 | Use various statistical methods for experimental data. |
| CO3 | Knowledge about the different types of the radiation detectors and their applications. |
| CO4 | Introduced to neutron physics, methods to detector slow and fast neutrons. |
| CO5 | Equipped with the basic knowledge about the experimental methods used in the various laboratories across the world. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | - | - | 2 | - | 1 | - | - | 1 | - | 1 | 1 | 1 |
| CO2 | - | - | - | 3 | - | - | - | 3 | 1 | 1 | 1 | 1 |
| CO3 | - | - | 1 | 2 | 3 | - | 1 | 3 | 2 | 2 | 2 | 2 |
| CO4 | - | - | 1 | 3 | 3 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| CO5 | - | - | 1 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |

**Detailed Syllabus:**

1. **Detection of radiations:** Interaction of gamma-rays, electrons, heavy charged particles, neutrons, neutrinos and other particles with matter. General properties of Radiation detectors, energy resolution, detection efficiency and dead time. Statistics and treatment of experimental data. *(Lectures 8)*

2. **Detectors:** Gas-filled detectors, Proportional counters, space charge effects, energy resolution, time characteristics of signal pulse, position-sensitive proportional counters, Multiwire proportional chambers, Drift chamber, Time projection chamber. Organic and inorganic scintillators and their characteristics, light collection and coupling to photomultiplier tubes and photodiodes, Semiconductor detectors, Ge and Si(Li) detectors, Charge production and collection processes, Pulse height spectrum, General background and detector shielding. *(Lectures 16)*

3. **Applications of Detectors:** Description of electron and gamma ray spectrum from detector, semiconductor detectors in X- and gamma-ray spectroscopy, Compton-suppressed, Semiconductor detectors for charged particle spectroscopy and particle identification. *(Lectures 8)*

4. **Experimental methods:** Large gamma and charge particle detector arrays, heavy-ion reaction analysers, production of radioactive ion beams. Detector systems for high energy experiments: Collider physics (brief account), Particle Accelerators (brief account), Modern Hybrid experiments- CMS . *(Lectures 8)*

**Text Books:**

1. Techniques in Nuclear and particle Experiments by W.R. Leo (Springer), 1994.

**Reference Books:**

1. Radiation detection and measurement by Glenn F. Knoll (Wiley), 2010.
2. Introduction to Experimental Particle Physics by Richard Fernow (Cambridge University Press), 2001.
3. Detectors for particle radiation by Konrad Kleinknecht (Cambridge University Press), 1999.

Elective Subject -III

| MSPH543-18 | Superconductivity and Low Temperature Physics | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** course in Condensed Matter Physics

**Course Objectives:** The objective of the course on Superconductivity and Low Temperature Physics is to build fundamental as well as advanced understanding in the field of superconductivity. Students will not only learn theoretical aspects but also acquainted with latest trends in the experimental techniques as well. Low temperature is one of the most versatile and important tool to explore rich physics of superconductivity. With latest technology the lowest achievable temperature now is close to few μK. Students will also be introduced to the theoretical background of low temperature techniques as well as the high-Tc superconductors.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| CO1 | Theoretical understanding of the concept of superconductivity. |
| CO2 | Correlate observed experimental properties of superconductors with origin of superconductivity. |
| CO3 | Describe appropriate theoretical model for describing behavior of superconductors. |
| CO4 | Provide exposure to High Tc class of superconductors and theoretical understanding of low temperature techniques. |
| CO5 | Provide exposure about the experimental techniques for measurement of superconductivity. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 3 |
| CO3 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | - | - | 3 |
| CO3 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | - | 2 | - | 3 | 3 |
| CO4 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | - | 2 | 2 | 2 | 3 |
| CO5 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 3 | 3 |

**Detailed Syllabus:**

1. **Superconductivity:** Introduction, Thermodynamics, The London Equations, penetration depth, Superconductors in magnetic field, Ginzberg-Landau Theory, Type I and II superconductors, BCS theory, second quantization, Cooper Pairing, energy gap Tunnelling, Josephson effects and SIS tunneling. *(Lectures 10)*

2. **Preparation and measurement techniques:** Single crystal growth: Optical image furnace, seeded melt growth, Thin film deposition: Pulsed laser deposition, sputtering, Resistivity measurements, magnetic measurements, Point contact spectroscopy, scanning tunneling microscopy and spectroscopy. *(Lectures 10)*

3. **Cryogenics:** Thermal and electrical properties of different materials at low temperatures, Cooling methods above 1K, Joule-ThomPOn, Gifford-McMohan, Evaporation cooling, Liquefication of Helium, Cooling methods below 1K, dilution refrigeration, adiabatic demagnetisation. *(Lectures 10)*

4. **Introduction to high-Tc superconductors:** Discovery of high-Tc superconductors, Mechanisms of superconductivity in high-Tc superconductors, Introduction to high-Tc superconducting compound like YBCO, Synthesis, Structure and properties, Electronics and applications. *(Lectures 10)*

**Text Books:**

1. Introduction to superconductivity: Michael Tinkham, Courier Corporation, 2004.

**Reference Books:**

1. Introduction to superconductivity: *A.C. Rose-Innes and E.H. Rhoderick,* Pergamon Press, 2004.
2. Experimental techniques in low temperature physics: *G.K. White and P.J. Meeson,* Oxford Univ. Press, 2001.
3. Experimental low temperature physics: *A. Kent,* MacMillan Press, 1992.
4. The theory of superconductivity in high-TC Cuprates: *P.W. Anderson,* Princeton Series Publications.

## Elective Subject -IV

| **MSPH544-18** | **Advanced Condensed Matter Physics** | **L-3, T-1, P-0** | **4 Credits** |
|---|---|---|---|

**Pre-requisite:** course on Condensed Matter Physics

**Course Objectives:** The objective of the course on **Advanced Condensed Matter Physics** is to familiarize the M.Sc. students with relatively advanced topics like optical properties, magnetism, superconductivity, magnetic resonance techniques and disordered solids so that they are confident to use the relevant techniques in their later career.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Comprehend and describe the Optical properties of solids employing macroscopic theories. |
| **CO2** | Explain various types of magnetic phenomenon in solids, underlying physics, and correlation with the applications. |
| **CO3** | Understand and realize the use of NMR methods for describing solids. |
| **CO4** | Interpret the phenomena, behavior and applications of superconductors. |
| **CO5** | Figure out and perceive the effect of deformation and disorder on the behavior of solids |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 3 |
| **CO2** | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 1 | 2 | 3 |
| **CO3** | 3 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 |
| **CO4** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| **CO5** | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 3 |

**Detailed Syllabus:**

1. **Optical Properties:** Macroscopic theory; Reflectance and Transmittance of a slab; generalized susceptibility, Kramers- Kronig relations, Brillouin scattering, Raman effect in crystals; interband transitions. (Lectures 8)

2. **Magnetism:** Dia and para-magnetism in materials; Langevin theory of diamagnetism, quantum theory of diamagnetism and paramagnetism, Exchange interaction. Heisenberg Hamiltonian; Hubbard model; mean field theory; Ferro-, ferri- and antiferromagnetism; Magnons: spin waves, thermal excitation of magnons; Bloch T2/1 law. (Lectures 8)

3. **Nuclear Magnetic Resonance in Solids:** Origin of NMR in solids– equations of motion, line width, motional narrowing, Knight shift. (Lectures 8)

4. **Superconductivity:** Experimental Survey; Basic phenomenology; Vortex state of a Type II superconductors; BCS pairing mechanism and nature of BCS ground state; Flux quantization; Tunneling Experiments; High Tc superconductors; Ginzburg-Landau theory; Greens functions at zero temperature; Applications of Greens functions to superconductivity. (Lectures 8)

5. **Disordered Solids:** Basic concepts in point defects and dislocations; Noncrystalline solids: diffraction pattern, Glasses, Amorphous semiconductors and Ferromagnets, Heat capacity and Thermal conductivity of amorphous solids; Quasicrystals. (Lectures 8)

**Text Books:**

1. Introduction to Solid State Physics: C. Kittel (Wiley, New York) 2005.
2. Quantum Theory of Solids: C. Kittel (Wiley, New York) 1987.

**Reference Books:**

1. Principles of the Theory of Solids: *J. Ziman (Cambridge University Press) 1971.*
2. Solid State Physics: *H. Ibach and H. Luth (Springer, Berlin), 2rd. ed. 2001.*
3. A Quantum Approach to Solids: *P.L. Taylor (Prentice-Hall, Englewood Cliffs), 1970.*
4. Intermediate Quantum Theory of Solids: *A.O.E. Animalu (East-West Press, New Delhi),1991.*
5. Solid State Physics : *Ashcroft and Mermin (Reinhert& Winston, Berlin), 1976.*

**Elective Subject -IV**

| MSPH545-18 | Advanced Particle Physics | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** Knowledge of particle physics

**Course Objectives:** The objective of the course on **Advanced Particle Physics** is to expose the students of M.Sc. class to the relatively advanced topics related to symmetry breaking in quantum field theory, standard model of particle physics, QCD and quark model, and various unification schemes so that they understand these aspects properly and are well equipped to pursue a career in high energy physics.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Understand various global and local gauge symmetries of system, invariance of action, symmetry breaking, and Higgs mechanism. |
| **CO2** | Need for standard model of particle physics and its limitations and the properties of QCD. |
| **CO3** | Define the problem of divergencies in quantum field theories and the renormalisation methods. |
| **CO4** | Asymptotic freedom and infrared slavery of the running coupling constant in non-abelian gauge theory of strong interactions -QCD. |
| **CO5** | Given exposure about the physics beyond the Standard Model. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | - | 2 | 1 | 2 | 2 |
| **CO2** | 2 | 1 | 1 | 2 | 2 | 2 | 2 | - | 2 | 1 | 2 | 2 |
| **CO3** | 1 | 2 | 1 | 2 | 2 | 2 | 2 | - | 2 | 3 | 1 | 2 |
| **CO4** | 1 | 1 | 2 | 1 | 2 | 2 | 2 | - | 1 | 2 | 1 | 2 |
| **CO5** | 1 | 2 | 2 | 1 | 2 | 2 | 2 | - | 2 | 2 | 3 | 2 |

**Detailed Syllabus:**

1. **Symmetries and Symmetry Breaking in QFT:** Continuous groups: Lorentz group SO(1,2) and its representations, Unitary groups and Orthogonal groups and their representations, Discrete symmetries: Parity, Charge Conjugation and Time reversal Invariance, CP, CPT. (Lectures 10)

2. **Global and Local invariances of the Action:** Approximate symmetries, Noethers theorem, Spontaneous breaking of symmetry and Goldstone theorem, Higgs mechanism, Abelian and Non-Abelian gauge fields, Lagrangian and gauge invariant coupling to matter fields. (Lectures 10)

3. **Standard Model of Particle Physics:** SU(2) x SU(1) x U(1) gauge theory, Coupling to Higgs and Matter fields of 2 generations, Gauge boson and fermion mass generation via spontaneous symmetry breaking, CKM matrix, Low energy Electroweak effective theory and Decoupling, Elementary electroweak scattering processes. (Lectures 10)

4. **QCD and quark model:** Asymptotic freedom and Infrared slavery, confinement hypothesis, Approximate flavor symmetries of the QCD lagrangian, Classification of hadrons by flavor symmetry: SU(1) and SU(2) multiplets of Mesons and Baryons, Chiral symmetry and chiral symmetry breaking, Sigma model, Parton model and Deep inelastic scattering structure functions. (Lectures 10)

**Text Books:**

1. Gauge Theory of Elementary Particle Physics: T.P Cheng & L.F. Li (Oxford).
2. An Introductory Course of Particle Physics: Palash Pal (CRC Press).

**Reference Books:**

1. First Book of Quantum Field Theory: A. Lahiri & P. Pal, Narosa, New Delhi.
2. Introduction to Quantum Field Theory: M. Peskin & D.V. Schroeder. (Levant Books).
3. Dynamics of the Standard Model: J.F. Donoghue (Cambridge University Press).

**Elective Subject -IV**

| **MSPH546-18** | **Environmental Physics** | **L-3, T-1, P-0** | **4 Credits** |
|---|---|---|---|

**Pre-requisite:** Knowledge of classical physics

**Course Objectives:** The aim of the course in **Environmental Physics** to expose the students to of M Sc physics to the recent advancements in this field so that they understand these aspects properly and are well equipped to pursue a career in environment physics and other related fields.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Understand the different types of pollution that occur in the Earth's environment |
| **CO2** | Apply the laws of radiation to Solar and Terrestrial Radiation |
| **CO3** | Describe the main reservoirs and exchanges in the global carbon cycle and explain the challenges involved in reducing CO2 emissions |
| **CO4** | Application in the Renewable sources of energy |
| **CO5** | Describe how pollution and climate are modelled on different scales, ranging from the local environment to the global Earth system. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 3 |
| **CO2** | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO3** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 |
| **CO4** | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | - | 3 |
| **CO5** | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

**Detailed syllabus:**

1. **Essentials of Environmental Physics**: Structure and thermodynamics of the atmosphere, Composition of air, Greenhouse effect, Transport of matter, energy and momentum in nature, Stratification and stability of atmosphere, Lass of motion, hydrostatic equilibrium, General circulation of the topics, Elements of weather and climate of India.

2. **Solar and Terrestrial Radiation:** Physics of radiation, Interaction of light with matter, tayleigh and Mie scattering, Laws of radiation (Kirchoffs law, Planck's law, Beer's law, Wien's displacement law, etc.), Solar and terrestrial spectra, UV radiation, Ozone depletion problem, IR absorption energy balance of the earth atmosphere system.

3. **Environmental Pollution and degradation:** Elementary fluid dynamics, Diffusion, Turbulence and turbulent diffusion, Factors governing air, Water and noise pollution, Air and water quality standards, Waste disposal, Heat island effect, Land and sea breeze, Puffs and plumes, Gaseous and particulate matters, Wet and dry deposition.

4. **Environmental Changes and remote sensing:** Energy sources and combustion processes, Renewable sources of energy, Solar energy, Wind energy, bioenergy, hydropower, fuel cells, nuclear energy, Forestry and bioenergy.

5. **Global and Regional Climate:** Elements of weather and climate, Stability and vertical motion of air, Horizontal motion of air and water, Pressure gradient forces, Viscous forces, Reynolds number, Enhanced Greenhouse Effect, Energy balance-a Zero-dimensional Greenhouse model, Global climate models.

**Suggested Readings/Books :**

1. Egbert Boeker & Rienk Van Groundelle: Environmental Physics (John Wiley).
2. J. T Hougtion: The Physics of atmosphere (Cambrige University Press, 1977).
3. J Twidell and J Weir: Renewable energy Resources (Elbs, 1988).
4. Sol Wieder: An introduction t solar energy for scientists and Engineers (John Wiley, 1982)
5. R. N. Keshavamurthy and M. Shanker Rao: The Physics of Monsoons (Allied Publishers, 1992).
6. G.J. Haltiner and R.T. Williams: Numerical Weather Prediction (John Wiley, 1980).

| **MSPH547-18** | **Dissertation** | **L-0, T-12, P-0** | **12 Credits** |
|---|---|---|---|

**Pre-requisite:** Knowledge of specific branch of physics

**Course Objectives:** The aim of the **M.Sc.** Research project work or Dissertation is to expose the students to preliminaries and methodology of research in Theoretical Physics and Experimental Physics. Students get the opportunity to participate in some ongoing research activity and development of a laboratory experiment.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Explain the significance and value of problem in physics, both scientifically and in the wider community. |
| **CO2** | Design and carry out scientific experiments as well as accurately record the results of experiments. |
| **CO3** | Critically analyse and evaluate experimental strategies, and decide which is most appropriate for answering specific questions. |
| **CO4** | Research and communicate scientific knowledge in the context of a topic related to condensed matter physics/Nuclear/High Energy Physics, in oral, written and electronic formats to both scientists and the public at large. |
| **CO5** | Explore new areas of research in physics and allied fields of science and technology. |

**Mapping of course outcomes with the program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 1 | 3 | 1 | 2 | 2 | 2 | 2 | 3 | 2 | 3 |
| **CO2** | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 |
| **CO3** | 2 | 2 | 2 | 2 | 2 | 2 | | 2 | 2 | 2 | 1 | 3 |
| **CO4** | 1 | 1 | - | 1 | | 2 | 2 | 2 | 2 | 3 | 1 | 3 |
| **CO5** | - | 2 | 2 | 1 | - | 1 | | 2 | 2 | | 2 | 2 |

**Guidelines for the Dissertation:**

The aim of project work in M.Sc. 4th semesters is to expose the students to preliminaries and methodology of research and as such it may consist of review of some research papers, development of a laboratory experiments, fabrication of a device, working out some problem, participation in some ongoing research activity, analysis of data, etc.. Project work can be in Experimental Physics, Theoretical Physics, or Simulation(quantum based softwares, HPCC, etc.) based in the thrust as well as non-thrust research areas of the Department.

A student opting for this course will be attached to one teacher of the Department before the end of the 3rd semester. A report about the work done in the project (typed on both the sides of the paper and properly bound) will be submitted by a date to be announced by the Head of Department.

Assessment of the work done under the project will be carried out by a committee on the basis of effort put in the execution of the project, interest shown in learning the methodology, report prepared, grasp of the problem assigned and viva-voce/seminar, etc. as per course guidelines.

Annexure-B

## Draft Syllabus of Personality Development

**UNIT I**

**Building up and enrichment of Vocabulary**

Learning Derivatives, Prefixes and Suffixes; Homonyms & Homophones; Pairs/Group of words; Synonyms & Antonyms; One word substitution; Foreign words & Phrases

**UNIT II**

**Application of Business Communication**

**(a) Speaking Module**

- Oral communication-Everyday Interactions, Group Discussions, Public speaking;
- Conversation Skills; Business Etiquette;
- Presentation Skills- combating stage fright, preparing power point presentations
- Non- Verbal Communication in Oral & Power Point Presentations; Telephonic Skills;
- Preparation for job interview- practice through mock interview

**(b) Mechanics of Writing**

- Descriptive and argumentative essays,
- Scientific & Technical Writing- writing abstracts & summaries, research papers;
- Writing business letters, emails; memos;
- Drafting Reports- training reports, project reports, varied business reports;
- Career Documents: Preparing a selling resume, covering letters, CVs, Preparing Portfolio etc.

**Suggested Readings:**


1. Practical English Usage. Michael Swan. OUP. 1995.
2. On Writing Well. William Zinsser. Harper Resource Book. 2001
3. Study Writing. Liz Hamp-Lyons and Ben Heasly. Cambridge University Press. 2006.
4. Communication Skills. Sanjay Kumar and Pushp Lata. Oxford University Press. 2011.
5. Exercises in Spoken English. Parts. I-III. CIEFL, Hyderabad. Oxford University Press
6. English Language Skills. Aruna Koneru. McGraw Hill Education (India) Private Limited. 2015.

# B.Sc. (Hons.) Physics

## Course Structure and Syllabus
## (Based on Choice Based Credit System)
## 2019 onwards

**SEMESTER FIRST**

| Course Code | Course Title | Load Allocation | | | Marks Distribution | | Total Marks | Credits |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | Internal | External | | |
| BSHPXXX-19 | Optics | 3 | 1 | - | 40 | 60 | 100 | 4 |
| BSHPXXX-19 | Mechanics | 3 | 1 | - | 40 | 60 | 100 | 4 |
| BSHPXXX-19 | Mathematics-I | 3 | 1 | - | 40 | 60 | 100 | 4 |
| BSHPXXX-19 | Chemistry-I | 3 | 1 | - | 40 | 60 | 100 | 4 |
| BSHPXXX-19 | Communicative English -I | 3 | 1 | - | 20 | 30 | 50 | 2 |
| BSHPXXX-19 | Punjabi Compulsory-I or Mudhli Punjabi-I | 2 | - | - | 20 | 30 | 50 | 2 |
| BSHPXXX-19 | Physics Lab-I | - | - | 6 | 50 | 25 | 75 | 3 |
| BSHPXXX-19 | Chemistry Lab-I | - | - | 4 | 30 | 20 | 50 | 2 |
| **TOTAL** | | **16** | **4** | **10** | **280** | **345** | **625** | **25** |

**L: Lectures T: Tutorial P: Practical**

## SEMESTER SECOND

| Course Code | Course Title | Load Allocation | | | Marks Distribution | | Total Marks | Credits |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | Internal | External | | |
| BSHPXXX-19 | Waves and Vibrations | 3 | 1 | - | 40 | 60 | 100 | 4 |
| BSHPXXX-19 | Electricity and Magnetism | 3 | 1 | - | 40 | 60 | 100 | 4 |
| BSHPXXX-19 | Mathematics-II | 3 | 1 | - | 40 | 60 | 100 | 4 |
| BSHPXXX-19 | Chemistry-II | 3 | 1 | - | 40 | 60 | 100 | 4 |
| BSHPXXX-19 | Communicative English -II | 2 | - | - | 20 | 30 | 50 | 2 |
| BSHPXXX-19 | Punjabi Compulsory-I or Mudhli Punjabi-II | 2 | - | - | 20 | 30 | 50 | 2 |
| BSHPXXX-19 | Physics Lab-II | - | - | 6 | 50 | 25 | 75 | 3 |
| BSHPXXX-19 | Chemistry Lab-II | - | - | 4 | 30 | 20 | 50 | 2 |
| TOTAL | | 16 | 4 | 10 | 280 | 345 | 625 | 25 |

**L: Lectures T: Tutorial P: Practical**

| **BSHPXXX-19** | **Optics** | **L-3, T-1, P-0** | **4 Credits** |
|---|---|---|---|

**Pre-requisite:** Understanding of senior secondary level Physics and Mathematics

**Course Objectives:** The objective of the course is to develop basic understanding of Interference, Diffraction and Polarization among students. The Students also learn about the LASER and its applications. Students will be equipped with knowledge to measure wave length, refractive index and other related parameters, which will act as a strong background if he/she chooses to pursue research in physics as a career.

**Detailed Syllabus:**

### *PART-A*

**UNIT I**

**Interference:** Definition and properties of wave front, Temporal and Spatial Coherence, Young's double slit experiment, Lloyd's single mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films, Fringes of equal inclination (Haidinger Fringes), Newton's Rings: Measurement of wavelength and refractive index, Interferometer: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, Fabry-Perot interferometer. (12 Lectures)

**UNIT-II**

**Diffraction:** Huygens Principle, Huygens-Fresnel Diffraction theory, Fraunhofer diffraction: Single slit. Circular aperture, Rayleigh criterion of resolution, Resolving Power of a telescope, Double slit, Multiple slits, Diffraction grating, Resolving power of grating. Fresnel Diffraction: Fresnel's Assumptions, Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light, Theory of a Zone Plate: Multiple Foci of a Zone Plate, Fresnel diffraction pattern of a straight edge and circular aperture. (11 Lectures)

### *PART-B*

**UNIT-III**

**Polarization:** Plane polarized light, Representation of Unpolarized and Polarized light, Polarization by Reflection, Brewster's law, Malus Law, Polarization by Selective absorption by Crystals, Polarization by Scattering, Polarization by Double Refraction, Nicol Prism, Huygen's theory of Double Refraction, Polaroid, Elliptically and Circularly polarized lights, Quarter and Half wave plates. (11 Lectures)

**UNIT-IV**

**Laser and Application:** Lasers, Spontaneous emission, Stimulated absorption, Stimulated emission, Einstein coefficients, Einstein relations, Conditions for Laser actions, Population inversion, Different types of Laser Pumping mechanism: Optical Pumping, Electric Discharge and Electrical pumping, Resonators, Two, Three and Four level laser systems, Ruby laser, He-Ne gas Laser, Semiconductor laser, $CO_2$ laser, applications of laser: Holography, Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms.

(11 Lectures)

**Text and Reference Books:**

1. Optics: A.K. Ghatak (Tata-McGraw Hill), 1992.

2. Fundamentals of Optics: F.A. Jenkins and H.E. White (McGraw Hill), 1981.

| BSHPXXX-19 | Mechanics | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** Understanding of senior secondary level Physics and Mathematics

**Course Objectives:** The aim and objective of the course on Mechanics is to introduce the students to the formal structure of vector mechanics, harmonic oscillators, and mechanics of solids so that they can use these in Engineering as per their requirement. This will act as a strong background if he/she chooses to pursue higher studies in physics.

**Detailed Syllabus:**

**UNIT I:**

**Fundamentals of Dynamics:** Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. Momentum of variable-mass system: motion of rocket.

**Work and Energy:** Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Force as gradient of potential energy. Work done by non-conservative forces. Law of conservation of Energy. (12 Lectures)

**UNIT-II**

**Non-Inertial Systems:** Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.

**Collisions:** Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frame of refrences. (11 Lectures)

**UNIT-III**

**Gravitation and Central Force Motion:** Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and fields due to spherical shell and solid sphere. Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). (11 Lectures)

**UNIT-IV:**

**Special Theory of Relativity:** Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Minkowski space time, Relativisitic Kinematics. Energy-Momentum Four Vector.

(12 Lectures)

**Text and Reference Books:**


1. Mechanics, Berkeley Physics, Vol.1.C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
2. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
3. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
4. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons
5. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
6. Physics for scientists and Engineers with Modern Phys., J.W.Jewett, R.A.Serway, 2010. Cengage Learning
7. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

| BSHP121-19 | Vibrations and Waves | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** Understanding of senior secondary level physics and Mathematics

**Course Objectives:** The objective of the course provides an exposure about simple harmonic motions, damped harmonic motions and forced oscillations. Students learns about the different waves, propagation of waves in various mediums and reflection/transmission of waves at the interface of mediums.

**Detailed Syllabus:**

*PART-A*

**UNIT-I**

**Simple and Damped Harmonic Motion:** Simple harmonic motion, energy of a SHO, Compound pendulum, Torsional pendulum, Electrical Oscillations, Lattice Vibrations, Transverse Vibrations of a mass on a string, Anharmonic Oscillations. Damped simple harmonic motion, Decay of free Vibrations due to damping, types of damping, Determination of damping coefficients – Logarithmic decrement, relaxation time and Q-factor. Electromagnetic damping. (12 Lectures)

**UNIT-II**

**Forced Vibrations and Resonance**: Forced mechanical and electrical oscillator, Transient and Steady State Oscillations, Displacement and velocity variation with driving force frequency, Variation of phase with frequency resonance, Power supplied to forced oscillator by the driving force. Q-factor and band width of a forced oscillator, Electrical and nuclear magnetic resonances. (1 2 lectures)

*PART-B*

**UNIT-III**

**Coupled Oscillations**: Stiffness coupled oscillators, Normal coordinates and modes of vibrations. Inductance coupling of electrical oscillators, Normal frequencies, Forced vibrations and resonance for coupled oscillators, Masses on string-coupled oscillators.

**Waves in Physical Media**: Types of waves, wave equation (transverse) and its solution characteristics impedance of a string, Impedance matching, Reflection and Transmission of waves at boundary, Energy of vibrating string, wave and group velocity. (12 Lectures)

**UNIT-IV**

**Electromagnetic waves:** Physical interpretation of Maxwell's equations, E.M waves and wave equation in a medium having finite permeability and permittivity but with conductivity $\sigma = 0$. Poynting vector, Impedance of a dielectric to EM waves, EM waves in a conducting medium and skin depth, EM wave velocity in a conductor and anomalous dispersion, Response of a conducting medium to EM waves. Reflection and transmission of EM waves at a boundary of two dielectric media for normal and oblique incidence, Reflection of EM waves from surface of a conductor at normal incidence. (12 Lectures)

**Text and Reference Books:**

1. Text Book of Vibrations and Waves: S.P. Puri (Macmillan India), 2004.

2. The Physics of Vibrations and Waves: H.J. Pain (Wiley and ELBS), 1976.

| BSHP122-19 | Electricity and Magnetism | L-3, T-1, P-0 | 4 Credits |
|---|---|---|---|

**Pre-requisite:** Basic knowledge of Electricity and Magnetism at high school level.

**Course Objectives:** The objective of the course is to expose the students to the formal structure of electricity and magnetism so that they can use these as per their requirement.

**Course Outcomes:** At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Understand and describe the different concepts of electrostatics and magnetostsics |
| **CO2** | Apply the knowledge of Maxwell's equation and flow of electromagnetic waves in real problems. |
| **CO3** | Analyze the wave propagation in different media |
| **CO4** | Compare the different types of polarization |
| **CO5** | have a solid foundation in electromagnetism fundamentals required to solve problems and also to pursue higher studies. |

**Detailed Syllabus:**

*PART-A*

**UNIT I Review of Vector Analysis and Electrostatics:** scalar and vector product; gradient, divergence and curl and their significance; Gauss-divergence theorem and Stoke's theorem (statement only); Electrostatic field; electric flux; Gauss's law of electrostatics; Applications of Gauss law-Electric filed due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charge sheet; Electric potential as line integral of electric field, potential due to point charge and electric dipole; calculation of electric field from potential; Poisson's equation and Laplace's equation(Cartesian coordinate); Capacitance; capacitance of a spherical conductor and cylindrical capacitor, Energy per unit volume in electrostatic field, Dielectric medium, dielectric polarization and its types, Displacement vector, Boundary conditions *(12 Lectures)*

**UNIT-II Magnetostatics:** Magnetic flux; magnetic flux density; Faraday's law; magnetomotive force; Biot-Savart's law and its applications-straight conductor, circular coil, divergence and curl of magnetic field; Ampere's work law in differential form; Magnetic vector potential; ampere's force law; magnetic vector potential; Energy stored in a magnetic field, boundary conditions on magnetic fields. *(10 Lectures)*

*PART-B*

**UNIT-III Maxwell's Equations and Poynting Vector:** Equation of continuity for time varying fields; Inconsistency of ampere's law; concept of sinusoidal time variations (Phasor notation); Maxwell's equations with physical significance; Maxwell equations in free space, static field and in Phasor notation; Difference between displacement current and conduction current; Concept of Poynting vector; Poynting Theorem. *(11 Lectures)*

**UNIT-IV Electromagnetic Waves:** Wave equation in free space or non-conducting or lossless medium; wave equation for conducting medium; wave propagation in lossless and conducting medium (phasor form); Propagation characteristics of EM waves in free space, lossless and in conducting medium; Uniform plane waves and solution; relation between electric and magnetic fields of an electromagnetic wave; Linear, circular and elliptical polarization; depth of penetration, Reflection of waves by a perfect conductor: normal incidence and oblique incidence; Reflection and transmission of electromagnetic waves from a non-conducting medium-vacuum interface for normal incidence. *(12 Lectures)*

**Reference Books:**

(i) David Griffiths, Introduction to Electrodynamics, Pearson Education India Learning Private Limited; 4 edition.

(ii) Edward C Jordan and Keith G Balmain, Electromagnetic waves and radiating systems, Prentice Hall

(iii) Kraus John D, Electromagnetics, McGraw-Hill Publisher

(iv) W. Saslow, Electricity, magnetism and light, Academic Press

Annexure-D

| PHSS906-18 | Advanced Particle Physics | L-3, T-1, P-0 | 4 Credits |
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**Pre-requisite:** Knowledge of particle physics

**Course Objectives:** The objective of the course on **Advanced Particle Physics** is to expose the students of Ph.D. to the relatively advanced topics related to symmetry breaking in quantum field theory, standard model of particle physics, QCD and quark model, and various unification schemes so that they understand these aspects properly and are well equipped to pursue a career in high energy physics.

**Course Outcomes:** At the end of the course, the student will have

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|---|---|
| **CO1** | Understanding of various global and local gauge symmetries of system, invariance of action, symmetry breaking, and Higgs mechanism. |
| **CO2** | Need for standard model of particle physics and its limitations and the properties of QCD. |
| **CO3** | The problem of divergencies in quantum field theories and the renormalisation methods. |
| **CO4** | Asymptotic freedom and infrared slavery of the running coupling constant in non-abelian gauge theory of strong interactions -QCD. |
| **CO5** | Physics beyond the Standard Model Physics. |

**Detailed Syllabus:**

1. **Symmetries and Symmetry Breaking in QFT:** Continuous groups: Lorentz group SO(1,2) and its representations, Dirac, Weyl and Majorana fermions, Unitary groups and Orthogonal groups and their representations, Discrete symmetries: Parity, Charge Conjugation and Time reversal Invariance, CP, CPT. (Lectures 10)

2. **Global and Local invariances of the Action:** Approximate symmetries, Noethers theorem, Spontaneous breaking of symmetry and Goldstone theorem, Higgs mechanism, Abelian and Non-Abelian gauge fields, Lagrangian and gauge invariant coupling to matter fields. (Lectures 10)

3. **Standard Model of Particle Physics:** SU(2) x SU(1) x U(1) gauge theory, Coupling to Higgs and Matter fields of 2 generations, Gauge boson and fermion mass generation via spontaneous symmetry breaking, CKM matrix, Low energy Electroweak effective theory and Decoupling, Elementary electroweak scattering processes. (Lectures 10)

4. **QCD and quark model:** Asymptotic freedom and Infrared slavery, confinement hypothesis, Approximate flavor symmetries of the QCD lagrangian, Classification of hadrons by flavor symmetry: SU(1) and SU(2) multiplets of Mesons and Baryons, Chiral symmetry and chiral symmetry breaking, Parton model and Deep inelastic scattering structure functions. (Lectures 10)

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**Text Books:**

1. Gauge Theory of Elementary Particle Physics: T.P Cheng & L.F. Li (Oxford).
2. An Introductory Course of Particle Physics: Palash Pal (CRC Press).

**Reference Books:**

1. First Book of Quantum Field Theory: A. Lahiri & P. Pal, Narosa, New Delhi.
2. Introduction to Quantum Field Theory: M. Peskin & D.V. Schroeder. (Levant Books).
3. Dynamics of the Standard Model: J.F. Donoghue (Cambridge University Press).

| PHS907-18 | **Renewable Energy Resources** | **L-3, T-1, P-0** | **4 Credits** |
|---|---|---|---|

**Pre-requisite:** Understanding of semiconductor physics

**Course Objectives:** The aim and objective of the course on **Renewable Energy Resources** is to expose the Ph.D. students to the basics of the alternative energy sources like solar energy, hydrogen energy, etc.

**Course Outcomes:** At the end of the course, the student will be able to

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|---|---|
| **CO1** | Understand the energy demand of world & distinguish between traditional and alternative form of energy. |
| **CO2** | Describe the concept of solar energy radiation and thermal applications. |
| **CO3** | Analyze making of solar cell and its types. |
| **CO4** | Identify hydrogen as energy source, its storage and transportation methods. |
| **CO5** | Compare wind energy, wave energy and ocean thermal energy conversion. |

**Detailed Syllabus:**

1. **Introduction**: Production and reserves of energy sources in the world and in India, need for alternatives, renewable energy sources. *(Lectures 8)*

2. **Solar Energy**: Thermal applications, solar radiation outside the earth's atmosphere and at the earth's surface, Principal of working of solar cell, Performance characteristics of solar cell. Types of solar cell, crystalline silicon solar cell, Thin film solar cell, multijunction solar cell, Elementary ideas of perovskite solar cell, dye synthesized solar cell and Tandem solar cell, PV solar cell, module array, and panel, Applications. *(Lectures 11)*

3. **Hydrogen Energy**: Environmental considerations, solar hydrogen through photo electrolysis and photocatalytic process, physics of material characteristics for production of solar hydrogen. Storage processes, solid state hydrogen storage materials, structural and electronic properties of storage materials, new storage modes, safety factors, use of hydrogen as fuel; use in vehicles and electric generation, fuel cells. *(Lectures 10)*

4. **Other sources**: Nature of wind, classification and descriptions of wind machines, power coefficient, energy in the wind, wave energy, ocean thermal energy conversion (OTEC), system designs for OTEC, basic idea about biogas, biofuel, and biodiesel. *(Lectures 8)*

**Text Books:**

1. Solar Energy: *S.P. Sukhatme (Tata McGraw-Hill, New Delhi), 2008.*

**Reference Books:**

1. Solar Cell Devices: *Fonash (Academic Press, New York), 2010.*
2. Fundamentals of Solar Cells, Photovoltaic Solar Energy: *Fahrenbruch and Bube (Springer, Berlin), 1982.*
3. Photoelectrochemical Solar Cells : *Chandra (New Age, New Delhi).*