



Date :- 01/08/2024

### **NOTIFICATION**

Sub :- CBCS Syllabi of M. Sc. in Physics (Sem. III & IV)

Ref. :- Decision of the Academic Council at its meeting held on 27/07/2024.

The Syllabi of M. Sc. in Physics (Third and Fourth Semesters) as per **NATIONAL EDUCATION POLICY – 2020 (2023 Pattern)** and approved by the Academic Council as referred above are hereby notified for implementation with effect from the academic year 2024-25.

Copy of the Syllabi Shall be downloaded from the College Website  
([www.kcesmjcollege.in](http://www.kcesmjcollege.in))

**Sd/-**  
**Chairman,**  
**Board of Studies**

**To :**

- 1) The Head of the Dept., M. J. College, Jalgaon.
- 2) The office of the COE, M. J. College, Jalgaon.
- 3) The office of the Registrar, M. J. College, Jalgaon.

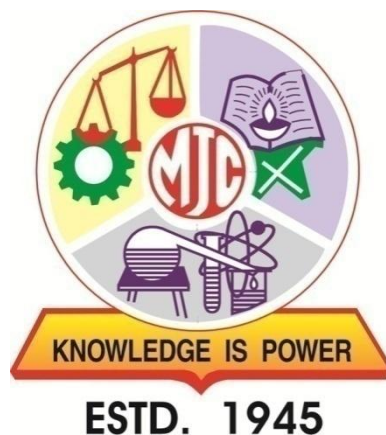
**Knowledge is Power**

Khandesh College Education Society's

# **Moolji Jaitha College, Jalgaon**

An "Autonomous College"

Affiliated to K.B.C. North Maharashtra University, Jalgaon



## **SYLLABUS**

# **S. Y. M. Sc. Physics**

**Under Choice Based Credit System (CBCS)  
and  
as per NEP-2020 Guidelines**

**[w.e.f. Academic Year : 2024-25]**

## Preface

Welcome to the Master of Physics program, all-inclusive and demanding academic journey designed to equip students with a deep understanding of the principles and applications of physics. This program is centered around a thoughtfully crafted syllabus, carefully curated to encompass the breadth and depth of the field.

In this program, we place a strong emphasis on the syllabus, recognizing its pivotal role in shaping the educational experience. Our aim is to provide you with a comprehensive foundation in theoretical concepts, practical skills, and advanced topics that are crucial for a successful career in physics.

The syllabus of our Master of Physics program has been meticulously designed to cover key areas such as classical mechanics, quantum mechanics, electromagnetism, statistical mechanics, and thermodynamics. Additionally, we offer a range of specialized elective courses, allowing you to delve deeper into specific areas of interest, such as condensed matter physics, particle physics, astrophysics, or optics.

Each course within the syllabus has been carefully crafted to provide a balance between theoretical knowledge and hands-on experience. Our dedicated faculty members, who are experts in their respective fields, will guide you through engaging lectures, laboratory experiments, and research projects that foster critical thinking, problem-solving abilities, and a deeper understanding of the subject matter.

Furthermore, we understand the importance of staying updated with the latest advancements in physics. Therefore, our syllabus is regularly reviewed and updated to incorporate cutting-edge research and emerging trends in the field. We believe that staying at the forefront of scientific knowledge is crucial for your success as a physicist.

We are confident that the syllabus-centric approach of our Master of Physics program will provide you with a solid foundation and prepare you for a rewarding career in academia, research, industry, or other related fields.

We wish you the best as you embark on this exciting educational journey and encourage you to make the most of the opportunities and resources available to you. Your dedication, passion, and curiosity will undoubtedly contribute to the advancement of knowledge and the betterment of our world.

**Program Outcomes (PO) for M.Sc. Program:**

Upon successful completion of the M.Sc. program, student will be able to:

| PO No. | PO                                                                                                                                                                                                                                                                                                                              |
|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1      | Student possesses an in-depth understanding of advanced theories, concepts, and methodologies in their specific field of study.                                                                                                                                                                                                 |
| 2      | Student should demonstrate advanced technical skills and proficiency in utilizing specialized equipment, software, and methodologies relevant to their field of study.                                                                                                                                                          |
| 3      | Student should be capable of critically analyzing complex problems and synthesizing information from various sources.                                                                                                                                                                                                           |
| 4      | Student should be proficient in effectively communicating scientific information to both technical and non-technical audiences. They should be able to present their experimental findings through oral presentations, scientific writing, and the use of appropriate visual aids.                                              |
| 5      | Student should demonstrate leadership qualities and the ability to work effectively as part of a team.                                                                                                                                                                                                                          |
| 6      | Student should have developed advanced research skills and the ability to independently design and conduct rigorous scientific investigations. They should be able to analyze scientific literature, formulate research questions, develop research plans, collect and analyze data, draw valid conclusions and know about IPR. |
| 7      | Student should understand and adhere to ethical principles and professional standards in their field.                                                                                                                                                                                                                           |
| 8      | Student should recognize the importance of continuous learning and professional development. They should have the skills and motivation to stay updated with advancements in their field, engage in lifelong learning, and pursue further academic or professional opportunities.                                               |

**Program Specific Outcome PSO (M.Sc. Physics):**

After completion of this course, students are expected to learn/understand the:

| PO No. | PSO                                                                                                                                 |
|--------|-------------------------------------------------------------------------------------------------------------------------------------|
| 1      | Graduates will possess a deep understanding of fundamental concepts and theory in physics                                           |
| 2      | Students will developed advanced research skill, including the ability to design and conduct experiments, collect and analyze data. |
| 3      | Students will gain proficiency in using sophisticated laboratory equipment.                                                         |
| 4      | Student will enhance problem solving skills using logical reasoning using mathematical modeling and computational techniques.       |
| 5      | Students will acquire in depth knowledge and expertise in the field of specialization.                                              |
| 6      | Students will develop communication skills both written and oral to present their scientific concepts to the audiences.             |

## Credit distribution structure for two years/one-year PG M.Sc. Programme

| Level                                                                                                                                   | Sem      | Major (Core) Subjects                                    |                                       | Minor Subjects | OJT/Int, RP | Cumulative Credits/Sem | Degree/ Cumulative Cr.             |
|-----------------------------------------------------------------------------------------------------------------------------------------|----------|----------------------------------------------------------|---------------------------------------|----------------|-------------|------------------------|------------------------------------|
|                                                                                                                                         |          | Mandatory (DSC)                                          | Elective (DSE)                        |                |             |                        |                                    |
| 6.0                                                                                                                                     | I        | DSC-1 (4T)<br>DSC-2 (4T)<br>DSC-3 (4T)                   | DSE-1(2T)<br>A/B                      | RM (4T)        |             | 22                     | First year PG OR                   |
|                                                                                                                                         | II       | DSC-5 (4T)<br>DSC-6 (4T)<br>DSC-7 (4T)                   | DSE-3(2T)<br>A/B                      |                | OJT/Int (4) | 22                     | One year PG diploma after 3year UG |
|                                                                                                                                         | Cum. Cr. | 28                                                       | 8                                     | 4              | 4           | 44                     |                                    |
| Exit option: PG diploma (44 Credits) after three year UG degree                                                                         |          |                                                          |                                       |                |             |                        |                                    |
| 6.5                                                                                                                                     | III      | DSC-9 (4T)<br>DSC-10 (4T)<br>DSC-11 (4T)                 | DSE-5(2T)<br>A/B                      | --             | RP (4)      | 22                     | Second year PG after 3 year UG OR  |
|                                                                                                                                         | IV       | DSC-13 (4T)<br>DSC-14 (4T)<br>DSC-15 (2P)<br>DSC-16 (2P) | DSE-7(2T)<br>A/B<br>DSE-8 (2P)<br>A/B | ...            | RP (6)      | 22                     | PG degree after 4 year UG          |
|                                                                                                                                         | Cum. Cr. | 54                                                       | 16                                    |                | 4+10        | 88                     |                                    |
| 2 Years-4 Sem. PG Degree (80-88 credits) after Three Year UG Degree or 1 Year-2 Sem PG Degree (40-44 credits) after Four Year UG Degree |          |                                                          |                                       |                |             |                        |                                    |

**Sem-** Semester, **DSC-** Department Specific Course, **DSE-** Department Specific Elective, **T-** Theory, **P-** Practical, **RM-** Research Methodology, **OJT-** On Job Training, **Int-** Internship, **RP-** Research Project, **Cum. Cr.:** Cumulative Credits

### Multiple Entry and Multiple Exit options:

The multiple entry and exit options with the award of three-year degree+ honours depending upon the number of credits secured;

| Levels | Qualification Title                                                          | Credit Requirements |         | Semester | Year |
|--------|------------------------------------------------------------------------------|---------------------|---------|----------|------|
|        |                                                                              | Minimum             | Maximum |          |      |
| 6.0    | Bachelor's Degree- Honours<br>Or<br>Bachelor's Degree- Honours with Research | 160                 | 176     | 8        | 4    |

# Examination Pattern for M.Sc.

## Theory Question Paper Pattern:

- 60 (External) +40 (Internal) for 4 credits
  - External examination will be of three hours duration
  - There shall be 5 questions each carrying equal marks (12 marks each) while the tentative pattern of question papers shall be as follows;
  - Q1 Attempt any 3 out of 4 sub-questions; each 4 marks
  - Q 2, Q3, Q4 and Q5 Attempt any 2 out of 3 sub-question; each 6 marks.
- 30 (External) +20 (Internal) for 2 credits
  - External examination will be of 1½ hours duration
  - There shall be 3 questions Q1 carrying 6 marks and Q2, Q3 carrying 12 marks each. while the tentative pattern of question papers shall be as follows;
  - Q1 Attempt any 2 out of 3 sub-questions; each 3 marks
  - Q 2 and Q3 Attempt any 2 out of 3 sub-question; each 6 marks.

## Rules of Continuous Internal Evaluation:

The Continuous Internal Evaluation for theory papers shall consist of two methods:

**1. Continuous & Comprehensive Evaluation (CCE):** CCE will carry a maximum of 30% weightage (30/15 marks) of the total marks for a course. Before the start of the academic session in each semester, the subject teacher should choose any three assessment methods from the following list, with each method carrying 10/5 marks:

- i. Individual Assignments
- ii. Seminars/Classroom Presentations/Quizzes
- iii. Group Discussions/Class Discussion/Group Assignments
- iv. Case studies/Case lets
- v. Participatory & Industry-Integrated Learning/Field visits
- vi. Practical activities/Problem Solving Exercises
- vii. Participation in Seminars/Academic Events/Symposia, etc.
- viii. Mini Projects/Capstone Projects
- ix. Book review/Article review/Article preparation
- x. Any other academic activity
- xi. Each chosen CCE method shall be based on a particular unit of the syllabus, ensuring that three units of the syllabus are mapped to the CCEs.

**2. Internal Assessment Tests (IAT):**IAT will carry a maximum of 10% weightage (10/5 marks) of the total marks for a course.IAT shall be conducted at the end of the semester and will assess the remaining unit of the syllabus that was not covered by the CCEs. The subject teacher is at liberty to decide which units are to be assessed using CCEs and which unit is to be assessed on the basis of IAT.

The overall weightage of Continuous Internal Evaluation (CCE + IAT) shall be 40% of the total marks for the course. The remaining 60% of the marks shall be allocated to the semester-end examinations.

The subject teachers are required to communicate the chosen CCE methods and the corresponding syllabus units to the students at the beginning of the semester to ensure clarity and proper preparation.

### **Practical Examination Credit 2: Pattern (30+20)**

#### **External Practical Examination (30 marks):**

- Practical examination shall be conducted by the respective department at the end of the semester.
- Practical examination will be of 3 hours duration and shall be conducted as per schedule.
- There shall be 05 marks for journal and viva-voce. Certified journal is compulsory to appear for practical examination.
- Practical examination will be of minimum 3 hours duration and shall be conducted as per schedule for 2 consecutive days in case of practical where incubation condition, allied aspects are essential.

#### **Internal Practical Examination (20 marks):**

- Internal practical examination of 10 marks will be conducted by department as per schedule given.
- For internal practical examination student must produce the laboratory journal of practicals completed along with the completion certificate signed by the concerned teacher and the Head of the department.
- There shall be continuous assessment of 30 marks based on student performance throughout the semester. This assessment can include quizzes, group discussions, presentations and other activities assigned by the faculty during regular practicals. For details refer internal theory examination guidelines.
- Finally 40 (10+30) marks performance of student will be converted into 20 marks.

**K.C.E. Society's**  
**Moolji Jaitha College Jalgaon**  
Department of Physics  
**Class - M.Sc. Physics**  
Course Structure

| M.Sc. - I  | Sem. | Type | Credit | TH/PR | Code         | Title                                                       |
|------------|------|------|--------|-------|--------------|-------------------------------------------------------------|
|            | I    | DSC  | 4      | TH    | PHY-DSC-511  | Mathematical Methods for Physics                            |
|            |      | DSC  | 4      | TH    | PHY-DSC-512  | Condensed Matter Physics                                    |
|            |      | DSC  | 4      | TH    | PHY-DSC-513  | Classical Mechanics                                         |
|            |      | DSE  | 2      | TH    | PHY-DSE-514A | Material Science                                            |
|            |      | DSE  | 2      | TH    | PHY-DSE-514B | Vacuum Technology                                           |
|            |      | DSC  | 2      | PR    | PHY-DSC-515  | Practical course on Mechanics and Condensed Matter          |
|            |      | DSE  | 2      | PR    | PHY-DSE-516A | Practical course on Material Science                        |
|            |      | DSE  | 2      | PR    | PHY-DSE-516B | Practical course on Vacuum Technology                       |
|            |      | DSC  | 4      | TH    | PHY-RM-517   | Research Methodology for Physics                            |
|            | II   | DSC  | 4      | TH    | PHY-DSC-521  | Special Theory of Relativity                                |
|            |      | DSC  | 4      | TH    | PHY-DSC-522  | Atomic and Molecular Physics-II                             |
|            |      | DSC  | 4      | TH    | PHY-DSC-523  | Quantum Mechanics-I                                         |
|            |      | DSE  | 2      | TH    | PHY-DSE-524A | Optical Fiber Communication                                 |
|            |      | DSE  | 2      | TH    | PHY-DSE-524B | MATLAB Programming                                          |
|            |      | DSC  | 2      | PR    | PHY-DSC-525  | Practical course on Quantum and Molecular Physics           |
|            |      | DSE  | 2      | PR    | PHY-DSE-526A | Practical course on Optical Fiber Communication             |
|            |      | DSE  | 2      | PR    | PHY-DSE-526B | Practical course on MATLAB Programming                      |
|            |      | DSC  | 4      | OJT   | PHY-OJT-527  | Internship / On Job Training                                |
| M.Sc. - II | III  | DSC  | 4      | TH    | PHY-DSC-611  | Quantum Mechanics-II                                        |
|            |      | DSC  | 4      | TH    | PHY-DSC-612  | Experimental Techniques in Physics- I                       |
|            |      | DSC  | 4      | TH    | PHY-DSC-613  | Nanotechnology                                              |
|            |      | DSE  | 2      | TH    | PHY-DSE-614A | Laser Fundamentals and Applications                         |
|            |      | DSE  | 2      | TH    | PHY-DSE-614B | Physics of Semiconductor Devices                            |
|            |      | DSC  | 2      | PR    | PHY-DSC-615  | Practicals on Nanotechnology and Experimental Techniques -I |
|            |      | DSE  | 2      | PR    | PHY-DSE-616A | Practicals on Laser Fundamentals and Applications           |
|            |      | DSE  | 2      | PR    | PHY-DSE-616B | Practicals on Physics of Semiconductor Devices              |
|            |      | DSC  | 4      | RP    | PHY-RP-617   | Research Project - I                                        |
|            | IV   | DSC  | 4      | TH    | PHY-DSC-621  | Nuclear Physics                                             |
|            |      | DSC  | 4      | TH    | PHY-DSC-622  | Experimental Techniques in Physics- II                      |
|            |      | DSE  | 2      | TH    | PHY-DSE-623A | Electronics Instrumentation                                 |
|            |      | DSE  | 2      | TH    | PHY-DSE-623B | Thin film Physics                                           |
|            |      | DSC  | 2      | PR    | PHY-DSC-624  | Practicals on Nuclear Physics                               |
|            |      | DSC  | 2      | PR    | PHY-DSC-625  | Practicals on Experimental Techniques in Physics- II        |
|            |      | DSE  | 2      | PR    | PHY-DSE-626A | Practicals on Electronics Instrumentation                   |
|            |      | DSE  | 2      | PR    | PHY-DSE-626B | Practicals on Thin film Physics                             |
|            |      | DSC  | 6      | RP    | PHY-RP-627   | Research Project - II                                       |

# **SEMESTER-III**

**MSc II (Physics)**  
**Semester III**  
**PHY-DSC-611 Quantum Mechanics-II**

**Total Hours: 60**

**Credits: 4**

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |              |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| <b>Course objectives</b> | <ul style="list-style-type: none"> <li>To understand the principles and mathematical framework of time-independent perturbation theory for non-degenerate and degenerate systems.</li> <li>To gain familiarity with time-dependent perturbation theory, including transition amplitudes, Fermi's golden rule, and the dipole approximation, WKB and the Born approximation.</li> <li>Explore the role of symmetry in quantum mechanics, including translations, parity, time reversal, and identical particles.</li> <li>Develop proficiency in using mathematical techniques such as partial waves, phase shifts, and Slater determinants to analyze quantum mechanical systems.</li> </ul>                                                                                                                                        |              |
| <b>Course outcomes</b>   | <p>After the completion of this course Students will be able to....</p> <ul style="list-style-type: none"> <li>Demonstrate proficiency in applying perturbation theory to solve problems in quantum mechanics, including calculating energy shifts and transition probabilities and analyze and interpret experimental results related to phenomena</li> <li>Apply approximation methods such as the variational method and WKB approximation to approximate solutions for complex quantum mechanical systems.</li> <li>Understand the principles of symmetry in quantum mechanics and its implications for the behavior of physical systems.</li> <li>Develop critical thinking and problem-solving skills through the application of advanced quantum mechanics concepts to real-world problems and experimental data.</li> </ul> |              |
| <b>Unit</b>              | <b>Topic Particular</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Hours</b> |
| <b>Unit I</b>            | <b>Approximation Methods I:</b> Time-independent Perturbation theory: Non degenerate, degenerate, Applications of Time-independent Perturbation theory - Stark effect, anharmonic oscillator. Introduction to Time-dependent Perturbation theory. Time dependent Perturbation theory: Transition amplitude, 1st and 2nd order, selection rules, Fermi's golden rule, Harmonic perturbation, dipole approximation, Einstein coefficient for spontaneous emission.                                                                                                                                                                                                                                                                                                                                                                    | 12           |
| <b>Unit II</b>           | <b>Approximation Methods II:</b> Variational method: Basic principles and application to hydrogen atom, helium atom (qualitative approach). WKB approximation: General formalism, Bound states for potential wells - with no rigid walls, with one rigid wall, with two rigid walls. Bohr's quantization condition, application to tunneling, field emission.                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 16           |
| <b>Unit III</b>          | <b>Theory of Scattering:</b> Collisions in 3-D and scattering: Laboratory and CM reference frames; scattering amplitude, differential scattering cross section and total scattering cross section: scattering by spherically symmetric potentials; Method of partial waves; Phase shift; Ramsauer-Townsend effect; scattering by a perfectly rigid sphere and by square well potential. Yukawa potential. The Born approximation, Lippman-Schwinger equation, applications and validity of the Born approximation.                                                                                                                                                                                                                                                                                                                  | 14           |
| <b>Unit IV</b>           | <b>Symmetry in Quantum Mechanics:</b> Symmetry in Quantum Mechanics, space and time translations, discrete lattice translations, parity, time reversal, discrete symmetries. Identical particles, symmetric and antisymmetric wave functions, Slater determinants, collision of identical particles, spin angular momentum, spin functions for systems with more than one electron. Wigner-Eckert theorem and its applications. Schrodinger and Heisenberg picture, Heisenberg's matrix mechanics for harmonic oscillator.                                                                                                                                                                                                                                                                                                          | 18           |

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <p><b>References</b></p> | <ul style="list-style-type: none"> <li>• Sakurai J. J. Modern Quantum Mechanics, edition 2, Addison Wesley 2011, ISBN 0805382917, 9780805382914.</li> <li>• Schiff L. I.. Quantum Mechanics, NY, McGraw-Hill, 1968.</li> <li>• Gasiorowicz S. Quantum Physics, Wiley International Edition, copyright 2003 ISBN 0-47142945-7.</li> <li>• Griffiths D. J. Introduction to Quantum Mechanics, Pearson Prentice Hall, 2005 ISBN 0131118927, 9780131118928.</li> <li>• Nouredine Zettili. Quantum Mechanics Concepts and Applications Jacksonville State University, Jacksonville, USA, Second Edition, Wiley 2009, ISBN 978-0-470-02678-6.</li> <li>• Landau L.D. and Lifshitz E.M. Quantum Mechanics Non-Relativistic Theory, Elsevier, 1981, Edition 3, ISBN 0080503489, 9780080503486.</li> <li>• Cohen-Tannaudji C., Diuand B. LaloeF.. Quantum Mechanics : Vols. I &amp; II , John Wiley ISBN: 978-0-471-16435-7.</li> <li>• Gottfried K.and Mow Yan T. Quantum Mechanics: Fundamentals, Springer Science &amp; Business Media, 2003, ISBN-0387955763, 9780387955766.</li> <li>• Pauling L. and Wilson E. B.. Introduction to Quantum Mechanics, McGraw Hill book company New York, 1935.</li> <li>• Crasemann B. and Powel J.D.. Quantum Mechanics, Addison-Wesley Pub. Co.[1961].</li> <li>• Messiah A.P. Quantum Mechanics -Vol. I &amp; II, Dover French North Holland 1961.</li> <li>• Dirac P. A. M.. The Principles of Quantum Mechanics, Clarendon Press, Oxford edition 4, 1981.</li> <li>• Levine I. Quantum Chemistry, Allyn and Bacon 1970.</li> <li>• Townsend J. A Modern Approach to Quantum Mechanics, University ScienceBooks, 2000, ISBN 1891389130.</li> <li>• Bowman G.E.. Essential Quantum Mechanics, Oxford University Press 2008 ISBN 0199228922, 9780199228928.</li> <li>• Bellac M. Le. Quantum Physics, Cambridge University Press 2006 ISBN 0521852773, 9780521852777.</li> </ul> |  |
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**MSc II (Physics)**  
**Semester III**  
**PHY-DSC-612: Experimental Techniques in Physics-I**

**Total Hours: 60**

**Credits: 4**

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| <b>Course objectives</b> | <ul style="list-style-type: none"> <li>To understand the concept of signals and signals analysis and different types of sensors.</li> <li>To understand the about the vacuum physics</li> <li>To understand the various techniques of vacuum and its pumping action.</li> <li>To impart the adequate knowledge about the vacuum measurement and low temperature techniques.</li> </ul>                                                                                                                                                            |              |
| <b>Course outcomes</b>   | After the completion of this course Students will be able to.... <ul style="list-style-type: none"> <li>Understand the signal analysis, errors and different types of sensors.</li> <li>Understand the field application of vacuum and various ranges of vacuum</li> <li>Know about various vacuum techniques and pumping action.</li> <li>Understand the concept of vacuum measurement and low temperature techniques.</li> </ul>                                                                                                                |              |
| <b>Unit</b>              | <b>Topic Particular</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Hours</b> |
| <b>Unit I</b>            | <b>Sensor, Signal and Signal Analysis:</b><br>Sensors, Sensor's characteristics, Classification of sensors, Operation principles of sensors such as electric, thermal, mechanical, pressure, gas and humidity with examples.<br>Signals, Signal analysis (Time and Frequency Domain), Signal to noise ratio, Measurement, result of a measurement, sources of uncertainty and experimental error, Systematic error, random error, Reliability-chi square test, Analysis of repeated measurement, Precision and accuracy, Elementary data fitting. | <b>16</b>    |
| <b>Unit II</b>           | <b>Vacuum Physics:</b><br>Importance and fields applications of vacuum, Kinetic theory of gases, Impingement rate of molecules on a surface, Average velocity of gas and mean free path, Gas transport properties (thermal conductivity, viscosity and diffusion), Various ranges of vacuum, Gas conductance of a vacuum line, Gas impedance of a vacuum line, Pumping speed, flow of gases through apertures, elbows, tubes etc. for viscous and molecular, flow regimes, Pump down time, Numericals.                                            | <b>17</b>    |
| <b>Unit III</b>          | <b>Vacuum Techniques:</b><br>Principles of Pumping concept, Types of Vacuum pumps: Rotary, Molecular drag, Oil diffusion, Cryogenic getter ion, Titanium sublimation, Sputter ion, Orbitron                                                                                                                                                                                                                                                                                                                                                       | <b>12</b>    |
| <b>Unit IV</b>           | <b>Vacuum Measurement and Low Temperature Techniques:</b><br>Vacuum gauges: McLeod, Thermocouple (Pirani), Penning gauges. Hot cathode ionization (triode type), Bayard-Alpert, Leak detection in vacuum pump, Low Temperature Techniques: Refrigeration principle (including thermodynamical aspects) and low temperature production techniques (Throttling process).                                                                                                                                                                            | <b>15</b>    |
| <b>References</b>        | <ul style="list-style-type: none"> <li>Rangan, C.S., Sarma, G.R. and Mani, V.S.V., Instrumentation: Devices and Systems, Tata Mc Graw Hill Publishing Co. Ltd.</li> <li>Delchar, T. A. Vacuum Physics and Techniques, Chapman and Hall.</li> <li>Roth, A.(1990), Vacuum Technology, North Holland, Elsevier Science B.V.</li> <li>Yarwood, J. (1967), High vacuum techniques, Chapman and Hall, London.</li> <li>Lounasmaa, O. U.(1974), Experimental principles and methods below 1 K, Academic Press, London and, New York.</li> </ul>          |              |

**MSc II (Physics)**  
**Semester III**  
**PHY-DSC-613: Nanotechnology**

**Total Hours: 60**

**Credits: 4**

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |              |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| <b>Course objectives</b> | <ul style="list-style-type: none"> <li>To introduce the concept of nanoscience and nanotechnology.</li> <li>To provide students with the knowledge of techniques used for synthesis and surface modification of nanomaterials with different properties of nanomaterials.</li> <li>To understand the importance and applications of nanotechnology.</li> <li>To understand the importance of nanomaterials in different field including defense and farming.</li> </ul>                                                                                                                                                                                                                         |              |
| <b>Course outcomes</b>   | <p>After the completion of this course Students will be able to....</p> <ul style="list-style-type: none"> <li>Understand chemical and biological experimental techniques used for synthesis and processing of nanomaterials.</li> <li>Understand the effect of size on properties of nanomaterials</li> <li>Understand the importance of nanomaterials and devices in energy conservation.</li> <li>Advanced materials used in agriculture, electronics, biomedical and food industries.</li> </ul>                                                                                                                                                                                            |              |
| <b>Unit</b>              | <b>Topic Particular</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Hours</b> |
| <b>Unit I</b>            | <b>Introduction to Nanoscience and Nanotechnology</b><br>Introduction to nanoscience and nanotechnology, History, background and interdisciplinary nature of nanoscience and nanotechnology, challenges of Richard Feynman, scientific revolutions, nanosized effects, surface to volume ratio, examples of surface to volume ratio, importance of nanoscale materials and their devices, zero dimensional, one-dimensional and two dimensional nanostructure materials, types of materials (conductor, semiconductors, insulator, types of semiconductor), ceramics and nanocomposites, quantum size effect (QSE) in 1D, 2D, 3D nanomaterials, quantum dots, nanowires, nanotubes, nanosheets. | <b>13</b>    |
| <b>Unit II</b>           | <b>Properties of Nanomaterials</b><br>Size dependent properties: surface to volume ratio, size effects on structure and morphology, quantum size effect, optical properties: fluorescence's, thermoluminescences, photoluminescence of nanoparticles, magnetic domain, interaction in magnetic material, random anisotropy, magnetic properties: particle size and magnetic behaviors, magnetic moment in nanoparticles, super paramagnetic effects, mechanical properties, thermal properties, electrical properties, super conductivity at nano scale.                                                                                                                                        | <b>12</b>    |
| <b>Unit III</b>          | <b>Synthesis of Nanomaterials</b><br>Physical method: ball milling synthesis, arc discharge, rf-plasma, plasma arch technique, inert gas condensation, laser pyrolysis, molecular beam epitaxy and electrodeposition. Electro-spinning, physical vapor deposition. chemical methods: co-precipitation, sol-gel method, chemical reduction, photochemical synthesis, electrochemical synthesis, microemulsions or reverse micelles, sono-chemical synthesis, hydrothermal, spray pyrolysis method, chemical vapor condensation, spin coating , introduction to biological methods                                                                                                                | <b>17</b>    |
| <b>Unit IV</b>           | <b>Application of Nanotechnology in Different Field</b><br>Nanotechnology for energy: photovoltaics cell, batteries, and fuel cells, supercapacitor, water purification: nano membranes, nano meshes, nano fibres, nano clays and adsorbents, zeolites, nano catalysts, food processing: nanofood, nanoencapsulation, nanocomposites in food packaging, agriculture: nano fertilizers,                                                                                                                                                                                                                                                                                                          | <b>18</b>    |

|                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
|                   | <p>nanopesticides, nanoseed, green building: self-cleaning coatings, anti-fogging and anti-icing coatings, antimicrobial coatings, Anti-corrosion coatings, automobile applications, aerospace applications: spacecraft and space structures, radiation shielding, nanotechnology in photonics, photonic crystals, plasmonics, and nano computers, nanotechnology in medical: drug delivery, nanodrugs for diagnosis and treatment of cancer, nano shells for surgery, nano artificial cells, nano biosensor, tissue engineering.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  |
| <b>References</b> | <ul style="list-style-type: none"> <li>• Fulekar, M. H. (2013). Nanotechnology importance and applications, I. K. International Publishing House.</li> <li>• Bandyopadhyay, A. K. (2010). Nanomaterials, New Age International Publishers, 2nd Edition.</li> <li>• Pradeep, T. (2007). NANO The Essential, understanding Nanoscience and Nanotechnology, Tata McGrawHill Publishing Company Limited.</li> <li>• Shareefraza, J. U., Puthiyillam P. (2018), Foundations of Nanoscale Science and Technology, LAP-Lambert Academic Publishing, Mauritius.</li> <li>• Minoli, D. (2013), Nanotechnology applications to telecommunications and networking, John Wiley &amp; Sons.</li> <li>• Rao, C. N. R., Thomas, P. J. and Kulkarni, G. U. (2007), Nanocrystals: Synthesis, Properties and Applications, Springer.</li> <li>• Linden, D. Reddy, T. B. (2002). Handbook of Batteries, 3rd Edition, McGraw-Hill.</li> <li>• Brabec, C., Dyakonov, V., and Scherf, U. (2014). Organic Photovoltaics: Materials, Device Physics, and Manufacturing Technology, 2nd Edition, Wiley VCH.</li> <li>• Puthiyillam, P. (2018). Applications of Nanotechnology, LAP Lambert Academic Publishing, Mauritius.</li> <li>• Karkare, M. (2008). Nanotechnology, Fundamentals and Applications, I.K. International Publishing, New Delhi.</li> </ul> |  |

**MSc II (Physics)**  
**Semester III**  
**PHY-DSE-614A: Laser Fundamentals and Applications**

**Total Hours: 30**

**Credits: 2**

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |              |
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| <b>Course objectives</b> | <ul style="list-style-type: none"> <li>To learn the fundamental concepts and characteristics of Laser.</li> <li>To learn and understand an importance of non-linear optic in Laser operation.</li> <li>To develop experimental knowledge of various types of atomic/molecular spectra.</li> <li>To learn the basic techniques of experimental spectroscopy.</li> </ul>                                                                                                                                                                                                      |              |
| <b>Course outcomes</b>   | After the completion of this course Students will be able to... <ul style="list-style-type: none"> <li>Know the theoretical and experimental background of atomic as well as molecular spectra.</li> <li>Understand various types of Lasers, their working and applications.</li> <li>Understand basic components of spectroscopic instruments and their functions.</li> <li>Know about measurements of atomic/molecular spectra using spectrometers.</li> </ul>                                                                                                            |              |
| <b>Unit</b>              | <b>Topic Particular</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Hours</b> |
| <b>Unit I</b>            | <b>Laser characteristics and Resonators:</b> Principles, Properties of laser radiation, Einstein Coefficients, Light amplification, Threshold condition for laser oscillations, Homogeneous and inhomogeneous broadening, Laser rate equations for 2,3 and 4 level, variation of laser power around threshold, optimum output coupling, Open planar resonator.                                                                                                                                                                                                              | <b>07</b>    |
| <b>Unit II</b>           | <b>Nonlinear optics:</b> Techniques for Q-switching, Mode Locking, Hole burning and Lamb dip in Doppler broadened Gas laser, Nonlinear oscillator model, Nonlinear polarization and wave equation, perturbative solution of the Nonlinear oscillator equation, Harmonic generation, Second harmonic generation, Phase matching third harmonic generation. Non-Linear susceptibilities, non-linear susceptibility tensor, non-linear materials.                                                                                                                              | <b>08</b>    |
| <b>Unit III</b>          | <b>Laser Systems:</b> Solid State Laser, Gas lasers, liquid lasers, Excimer lasers. Semiconductor Laser. Liquid –Dye and chemical lasers, high power laser systems and industrial applications.                                                                                                                                                                                                                                                                                                                                                                             | <b>06</b>    |
| <b>Unit IV</b>           | <b>Spectroscopic Instrumentation and applications:</b> Raman scattering, Raman Amplification and Raman laser, special techniques in nonlinear spectroscopy, polarization spectroscopy, multi-photon spectroscopy,. Holographic Optical Element: HOE, Design aspects, resolution, vibration and motion analysis by Holographic techniques, holography, Spatial Frequency filtering, optical Communication, optical computers.                                                                                                                                                | <b>09</b>    |
| <b>References</b>        | <ul style="list-style-type: none"> <li>B. Laud, Laser and Non-linear optics, Wiley Eastern Ltd., (1991).</li> <li>A.K. Ghatak and K. Thyagarajan, optical electronics, Cambridge University Press (1991).</li> <li>S.C Gupta Optoelectronic devices and systems , Prentice Hall of India.</li> <li>(WH) Wilson and Hawkes: Optoelectronics, Prentice Hall of India.</li> <li>Yariv, Optical Electronics in Modern Communications, Oxford University Press (1997),</li> <li>Laser Spectroscopy- Basic concepts and instrumentation by Demtroder (ed. 3, Springer)</li> </ul> |              |

**MSc II (Physics)**  
**Semester III**  
**PHY-DSE-614B: Physics of Semiconductor Devices**

**Total Hours: 30**

**Credits: 2**

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |              |
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| <b>Course objectives</b> | <ul style="list-style-type: none"> <li>To impart knowledge of charge current transport.</li> <li>To understand the mathematical design of Semiconductor Diode.</li> <li>To understand the theoretical design of Metal Semiconductor Diode.</li> <li>To understand the basic operational principle of BJT.</li> </ul>                                                                                                                                                                           |              |
| <b>Course outcomes</b>   | After the completion of this course Students will be able to.... <ul style="list-style-type: none"> <li>Understand current transport in device.</li> <li>Design Semiconductor Diode.</li> <li>Simulate Metal Semiconductor Diode.</li> <li>Understand the equivalent model and equations of BJT.</li> </ul>                                                                                                                                                                                    |              |
| <b>Unit</b>              | <b>Topic Particular</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Hours</b> |
| <b>Unit I</b>            | <b>Current Transport Phenomena and Continuity Equation:</b> Fermi Level in Semiconductors in Equilibrium, Drift of carriers, Drift current. Diffusion current, Total current density, Non-uniform impurity distribution and induced internal field. Einstein's relation, Non-equilibrium excess carriers and Continuity equation. Excess carrier generation, recombination and injection and its mathematical analysis using continuity equation, Concept of quasi Fermi levels.               | <b>08</b>    |
| <b>Unit II</b>           | <b>P-N Junctions -Characteristics</b> Junction in equilibrium, Continuity of Fermi level across the junction, Junction under forward and reverse bias, Zero bias, Built-in- potential, Electric field in depletion region, Space Charge width, Biased junction, Space charge width under electric field, Junction Capacitance, Diffusion capacitance, One sided junction, Non-uniformly doped junctions, Linearly graded, Hyper abrupt etc.                                                    | <b>07</b>    |
| <b>Unit III</b>          | <b>P-N Junctions Devices:</b> Break down in P-N junction, Avalanche and Zener Breakdown. a) PN Junction diode: Carrier distribution profile, Ideal P-N junction current, small signal equivalent, Current voltage characteristics of junction diode. b) Zener diode: Reverse bias breakdown, principle of operation, device design for particular breakdown voltage. c) Photovoltaic Cell: Principle of operation, forward and reverse bias characteristics, equivalent circuit, applications. | <b>08</b>    |
| <b>Unit IV</b>           | <b>Bipolar Junction Transistor:</b> Structure, basic principle of operation, Modes of operation, Carrier concentration profile in various regions in forward active mode, current gain and current gain factors, Equivalent circuit models: Ebers-Moll model, the dependence of Ebers-Moll parameters on the structure and operating point, Maximum transition current, Voltage and power rating.                                                                                              | <b>07</b>    |
| <b>References</b>        | <ul style="list-style-type: none"> <li>Neamen, D. A. (2021). Semiconductor Physics and Devices-Basic Principles, McGraw Hill, 4th ed.</li> <li>Sze, S. &amp; Lee, M. K. (2015). Semiconductor Devices, Physics and Technology, Wiley.</li> <li>King, A. R. (2003). Physics of Semiconductors, Springer-Verlag New York Inc.</li> </ul>                                                                                                                                                         |              |

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|  | <ul style="list-style-type: none"> <li>• Streetman, B. (2015). Solid State Electronic Devices Pearson, 7<sup>th</sup> ed.</li> <li>• Pierret, (2006). Semiconductor Device Fundamentals, Pearson, 1<sup>st</sup> ed.</li> <li>• Parasuraman, S. (2019). Semiconductor Materials Devices and Fabrications, Wiley.</li> </ul> |  |
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**MSc II (Physics)****Semester III****PHY-DSC-615: Practicals on Nanotechnology and Experimental Techniques-I****Total Hours: 60****Credits: 2**

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |              |
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| <b>Course Objectives</b> | <ul style="list-style-type: none"><li>• Students get to know the meaning of the nano in correlation to materials, understand the meaning of their size in comparison to bulk materials, atoms, and molecules.</li><li>• They learn about specific physio-chemical properties of nanomaterials and related applications.</li><li>• They learn basic physical techniques and chemical synthesis methods for the preparation of nanomaterials, and basic procedures for surface functionalization and coating of nanomaterials.</li><li>• They get an insight into characterization methods for nanomaterials.</li></ul>                                                                                     |              |
| <b>Course Outcomes</b>   | After the completion of this course Students will be able to.... <ul style="list-style-type: none"><li>• Understand the meaning of the expression nanomaterials in comparison to bulk materials, atoms, and molecules.</li><li>• Apply basic knowledge on physical and chemical procedures for the fabrication and synthesis of nanomaterials.</li><li>• Knowledge of the characterization methods of nanomaterials, the limitations related to their size and interpretation of the results &amp; basic surface functionalization and coating procedures for nanomaterials.</li><li>• Knowledge on interparticle interactions and assembly of nanoparticles into complex structures/materials.</li></ul> |              |
| <b>Sr. No.</b>           | <b>Topic Particular</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Hours</b> |
| 1                        | Hall effect–determination of carrier mobility and concentration in a semiconductor film                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 4            |
| 2                        | Synthesis of transition metal oxide nanoparticles by hydrothermal route.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 4            |
| 3                        | Optical characteristics of synthesized nano-material using photo spectrometer.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 4            |
| 4                        | Synthesis of graphene oxide from graphite powder by hummers method.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 4            |
| 5                        | Deposition of thin films using spin coater.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 4            |
| 6                        | Synthesis of metal oxide using CBD method.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 4            |
| 7                        | Synthesis of polymeric nanoparticles by solvent evaporation method and characterization.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 4            |
| 8                        | Synthesis of colloidal solution and demonstration of Tindal effect.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 4            |
| 9                        | Synthesis of CdS by chemical method.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 4            |
| 10                       | Synthesis of nano crystalline AgS.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 4            |
| 11                       | Synthesis of ZnO by chemical method.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 4            |
| 12                       | Green synthesis of Ag nano particles.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 4            |
| 13                       | Synthesis of Au/Ag nanoparticles using co-precipitation method.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 4            |
| 14                       | Synthesis of CdS nanoparticle using hydrothermal process.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 4            |
| 15                       | Synthesis of TiO <sub>2</sub> nanoparticles using sol-gel process.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 4            |
| 16                       | Synthesis of Fe <sub>2</sub> O <sub>3</sub> nanofibers using electrospinning.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 4            |

|                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |   |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 17                | To maintain different pressure ranges using vacuum pump                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 4 |
| <b>References</b> | <ul style="list-style-type: none"> <li>• Guozhong, Cao (2011). Nano structures and Nano materials, synthesis, properties and applications, world scientific series in nano science and technology, Vol. 2.</li> <li>• Rao, C. N. R.,Muller, A.,Cheetham, A. K. (2004). The Chemistry of Nano materials: Synthesis, Properties and Applications, WILEY-VCH Verlag GmbH &amp; Co. KgaA, Weinheim.</li> <li>• Shareefraza, J. U., Rai S., Puthiyillam, P. (2018) LAP Lambert Academic Publishing, Mauritius, Synthesis of Nanomaterials.</li> <li>• Pradeep, T. (2007), NANO The Essential, understanding Nano science and Nanotechnology. Tata Mc Graw-Hill Publishing Company Limited.</li> </ul> |   |

**MSc II (Physics)**  
**Semester III**  
**PHY-DSE-616A: Practicals on Laser Fundamentals and Applications**

**Total Hours: 60**

**Credits:2**

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |              |
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| <b>Course Objectives</b> | <ul style="list-style-type: none"> <li>To develops the students practical and technical skills required for physics experimentation.</li> <li>It develops students logical thinking, skill for data collection,</li> <li>Analysis and extracting relevant information from experimental outcomes.</li> <li>To give basic understanding regarding basic concepts LASER and it applications.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                 |              |
| <b>Course Outcomes</b>   | <p>After the completion of this course Students will be able to....</p> <ul style="list-style-type: none"> <li>Students will understand the concept of LASER and its applications as well as fundamental concepts related to optics.</li> <li>It develops student's skill for handling sophisticated and sensitive instrumentation.</li> <li>It develops deeper understanding of phenomenon related to optics such as diffraction, interference, polarization &amp; properties and application of LASER.</li> <li>Students can apply the practical knowledge in optical industries.</li> </ul>                                                                                                                                                                                                                                        |              |
| <b>Sr. No.</b>           | <b>Topic Particular</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Hours</b> |
| 1                        | To determine diameter of a given wire by diffraction.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 4            |
| 2                        | Verification of Brewster's law of polarization using He-Ne laser                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 4            |
| 3                        | To determine the wavelength of a LASER source using an engraved scale as a reflecting diffraction grating.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 4            |
| 4                        | Study of magneto-optic rotation and magneto-optic modulation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4            |
| 5                        | Measurement of reflectivity and transferability of thin film by using He-Ne laser.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 4            |
| 6                        | To verify Heisenberg uncertainty principle using He-Ne laser source.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 4            |
| 7                        | Determination of bandwidth of a given optical fiber                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 4            |
| 8                        | Determination of particle size of lycopodium particles by laser diffraction method                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 4            |
| 9                        | Measurement of Refractive Index of Liquids using Laser                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 4            |
| 10                       | Measurement of laser parameters.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 4            |
| 11                       | Laser interferometer to find the wavelength.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 4            |
| 12                       | Refractive index of the given materials.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 4            |
| 13                       | Refractive index of the Air at different pressure.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 4            |
| 14                       | Semiconductor lasers- Study of output characteristics and determination of threshold current, differential quantum efficiency and divergence.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4            |
| 15                       | Wavelength and Particle Size Determination.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 4            |
| 16                       | Measurement of Refractive Index of Liquids Using Laser                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 4            |
| <b>References</b>        | <ul style="list-style-type: none"> <li>Michelson Interferometer Advanced Practical Physics -Worsnop and Flint</li> <li>Analysis of sodium spectrum a Atomic spectra- H.E. White b Experiments in modern physics – Mellissinos</li> <li>h/e by vacuum photocell a Advance practical physics - Worsnop and Flint b Experiments in modern Physics – Mellissinos</li> <li>Study of He-Ne laser Measurement of divergence and wavelength a A course of experiments with Laser - Sirohi b Elementary experiments with Laser G. White</li> <li>Susceptibility measurement by Quincke's method /Guoy's balance method Advance practical physics - Worsnop and Flint</li> <li>Absorption spectrum of specific liquids Advance practical physics - Worsnop and Flint</li> <li>Coupled Oscillations HBCSE Selection camp 2007 Manual.</li> </ul> |              |

**MSc II (Physics)**  
**Semester III**  
**PHY-DSE-616B: Practicals on Physics of Semiconductor Devices**

**Total Hours: 60**

**Credits: 2**

|                          |                                                                                                                                                                                                                                                                                                                                   |              |
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| <b>Course objectives</b> | <ul style="list-style-type: none"> <li>To apply the concept of physics of Semiconductor devices.</li> <li>To understand the behavior of Semiconductor devices.</li> <li>To expertise in handling semiconductor devices in electronics circuit.</li> <li>To able to solve the fault in electronic circuit.</li> </ul>              |              |
| <b>Course outcomes</b>   | After the completion of this course Students will be able to.... <ul style="list-style-type: none"> <li>Understand current transport in device.</li> <li>Design circuit using Semiconductor Device.</li> <li>Handle semiconductor devices electronics circuit.</li> <li>Troubleshoot the fault in electronics circuit.</li> </ul> |              |
| <b>Sr. No.</b>           | <b>Topic Particular</b>                                                                                                                                                                                                                                                                                                           | <b>Hours</b> |
| 1                        | Measurement of Temperature dependent resistivity using Four Probe Method.                                                                                                                                                                                                                                                         | 4            |
| 2                        | Measurement of energy band gap.                                                                                                                                                                                                                                                                                                   | 4            |
| 3                        | Study of magneto resistance in semiconductor.                                                                                                                                                                                                                                                                                     | 4            |
| 4                        | Measurement of Thermal conductivity                                                                                                                                                                                                                                                                                               | 4            |
| 5                        | Determination of mobility using hall effect.                                                                                                                                                                                                                                                                                      | 4            |
| 6                        | Determination of hall coefficient using hall effect.                                                                                                                                                                                                                                                                              | 4            |
| 7                        | Study characteristics of PN junction diode.                                                                                                                                                                                                                                                                                       | 4            |
| 8                        | Study characteristics of Zener diode.                                                                                                                                                                                                                                                                                             | 4            |
| 9                        | Use a semiconductor parameter analyzer or a computer simulation tool. Measur the built-in potential ( $V_{bi}$ ) and the depletion width (W).                                                                                                                                                                                     | 4            |
| 10                       | Study characteristics of Photovoltaic Cell.                                                                                                                                                                                                                                                                                       | 4            |
| 11                       | To measure the forward voltage, drop of a Schottky diode.                                                                                                                                                                                                                                                                         | 4            |
| 12                       | To determine the ohmic nature of different conducting surfaces                                                                                                                                                                                                                                                                    | 4            |
| 13                       | To observe the reverse bias characteristics of a Schottky diode.                                                                                                                                                                                                                                                                  | 4            |
| 14                       | To observe the amplification properties of a Bipolar Junction Transistor (BJT).                                                                                                                                                                                                                                                   | 4            |
| 15                       | To study the switching characteristics of a Bipolar Junction Transistor (BJT).                                                                                                                                                                                                                                                    | 4            |
| 16                       | Simulation of P-N junction diode using MATLAB.                                                                                                                                                                                                                                                                                    |              |
| <b>References</b>        | <ul style="list-style-type: none"> <li>Neamen, D. A. (2021). Semiconductor Physics and Devices-Basic Principles, McGraw Hill, 4th ed.</li> <li>Sze, S. &amp; Lee, M. K. (2015). Semiconductor Devices, Physics and Technology, Wiley.</li> </ul>                                                                                  |              |

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|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
|  | <ul style="list-style-type: none"> <li>• King, A. R. (2003). Physics of Semiconductors, Springer-Verlag New York Inc.</li> <li>• Streetman, B. (2015). Solid State Electronic Devices Pearson, 7th ed.</li> </ul> |  |
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**MSc II (Physics)**  
**Semester III**  
**PHY- RP-617: Research Project-I**

**Total Hours: 120**

**Credit: 4**

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| <b>Course objectives</b> | <ul style="list-style-type: none"> <li>To give exposure to the students to research culture and technology.</li> <li>To introduce students to how to select a research topic, plan, perform experiments, collect and analyze the data.</li> <li>To foster self-confidence and self-reliance in the students as they learn to work and think independently.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |              |
| <b>Course outcomes</b>   | <p>After the completion of this course Students will be able to....</p> <ul style="list-style-type: none"> <li>Conceive a problem based on published research and conduct a comprehensive literature survey.</li> <li>Plan and carry out the tasks in the given framework of the dissertation and present the work in writing and viva.</li> <li>Learn handling of instruments, use of chemicals and how to conduct the experiments</li> <li>Learn how to present the project in PowerPoint and answer the queries to examiners and the science of writing.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |              |
| <b>Sr. No.</b>           | <b>Topic Particular</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Hours</b> |
|                          | <p><b>Credit distribution (1 credit for each unit)</b></p> <ul style="list-style-type: none"> <li>Identification of a research topic, formulation of research problem, objectives, sample size and hypothesis, etc.</li> <li>Preparation of Outline</li> <li>Review of literature</li> <li>Bibliography</li> </ul> <p><b>The systematic approach towards the execution of the project should be as follows: (Wherever applicable)</b></p> <ol style="list-style-type: none"> <li>The complete tenure of the research project should be one year. It should be allotted during the third semester and completed in the fourth semester.</li> <li>Weekly 8 hours should be allotted to the research project in a regular timetable.</li> <li>In the third semester, students will be evaluated based on a credit distribution mentioned above. In the fourth semester, students should perform further research work, collect and analyze the data, compile the results and prepare and submit the final dissertation.</li> <li>Students may be given an opportunity to participate in ongoing research activities in the respective Departments/Schools/Supervisors' laboratories. This will familiarize them with the literature survey and give them a fundamental understanding of designing and executing a research project.</li> <li>Students may work individually or in groups (not more than 3 students) to be decided by the concerned department/supervisor.</li> <li>Each research group should have a different research topic with some possible level of novelty.</li> <li>The student should select the topic relevant to priority areas of concern or allied subjects with the guidance of supervisor/ head of the department.</li> <li>Students are encouraged to work on multidisciplinary and applied projects, but it is not mandatory criteria.</li> <li>At the beginning, students should submit the outline of the research work to be carried out in the project. (Writing in order: Title, Aim and objectives, Literature to be collected, Experimental plan or method design, expected outcome etc.)</li> </ol> |              |

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |
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|  | <p><b>10.</b> Write and submit a Literature Review Report and Research outline<br/>Tentative order for review: Title of the Project, Certificates, Acknowledgment, Abstract and Keywords, Contents, Introduction, Literature Review, Aim of the Project, Materials and Methods, Bibliography/reference etc.<br/>Tentative order for research outline: Title page, introduction, background and significance of study, problems to be investigated, objective, hypothesis, chapter scheme, bibliography.</p> <p><b>11.</b> At the end of the third semester, each student should submit a detailed Literature Review Report and research outline.</p> <p><b>12.</b> An appropriate and essentialconclusive statement must be drawn at the end of the study.</p> <p><b>13.</b> Students should maintain lab notebooks, and the Supervisor may ask them to submit the mid-semester progress report.</p> <p><b>14.</b> For documents related to project submission: Font- Times New Roman, Heading Font Size-14, Normal Text Size-12, spacing-1.5, both sides justified and 1 inch margin on all side, both side printing on A-4 size.</p> <p><b>15.</b> Three copies of the Literature Review Report, research outline should be prepared (one copy for each department, guide, and student).</p> <p><b>16.</b> At the end of the semester, the candidate should prepare and present research work using a PowerPoint presentation with modern ICT tools and present the same in front of his/ her respective department during the Internal Examination.</p> <p><b>17.</b> For external examination the candidate will have to present the research work and face viva voce.</p> <p><b>18.</b> Students may present their research work in Avishkar/Webinars/Conferences.</p> <p><b>19.</b> Students should note that plagiarism is strictly prohibited.</p> <p><b>Internal examination (40 marks):</b> Components of continuous internal assessment:</p> <ul style="list-style-type: none"> <li>• Draft Research Outline (10 marks)</li> <li>• Draft Review of literature (10 marks)</li> <li>• Working Bibliography (10 marks)</li> <li>• PowerPoint presentation, and oral examination (10 marks)</li> </ul> <p><b>External examination (60 marks)</b>and Components of external assessment:</p> <ul style="list-style-type: none"> <li>• Final submitted review report, research outline in bound form at the time of examination <b>(40 marks)</b></li> <li>• Overall presentation reflecting the contribution of work, response to questions <b>(20 marks)</b></li> </ul> |  |
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# **SEMESTER-IV**

**MSc II (Physics)**  
**Semester IV**  
**PHY-DSC-621: Nuclear Physics**

**Total Hours: 60**

**Credits: 4**

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| <b>Course Objectives</b> | <ul style="list-style-type: none"> <li>To understand nuclear mass, binding energy, and charge radius measurements and learn about radioactivity and decay processes (alpha, beta, gamma).</li> <li>Familiarize with radiation detectors and their principles of operation.</li> <li>Understand nuclear models and their predictions.</li> <li>Gain knowledge of nuclear reactions and reactor dynamics.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                               |              |
| <b>Course outcomes</b>   | <p>After the completion of this course Students will be able to....</p> <ul style="list-style-type: none"> <li>Analyze experimental data on nuclear properties and interactions.</li> <li>Apply knowledge of radiation detectors to experimental design.</li> <li>Evaluate the principles and operation of nuclear reactors.</li> <li>Understand the fundamentals of particle physics and develop critical thinking skills through problem-solving in nuclear physics.</li> </ul>                                                                                                                                                                                                                                                                                                                                |              |
| <b>Unit</b>              | <b>Topic Particular</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Hours</b> |
| <b>Unit I</b>            | <b>General Properties and Concepts of Nuclei :</b> Nuclear Mass & Binding Energy, Systematics of Nuclear Binding Energy, Measurement of Charge Radius- Electron Scattering Experiment, Concept of Mass Spectrograph, Nuclear spin, Magnetic Dipole Moments & Electric Quadrupole Moments of Nuclei, Radioactivity, Unit of Radioactivity, Alpha Decay: Velocity of Alpha Particles, Disintegration Energy, Range-Energy Relationship, Geiger-Nuttal Law, Beta Decay: Conditions for Spontaneous Emission of $\beta^-$ & $\beta^+$ Particles, Selection Rules, Origin of Beta Spectrum-Neutrino Hypothesis, Gamma Decay: Decay Scheme of $^{137}\text{Cs}$ & $^{60}\text{Co}$ Nuclei, Internal Conversion, Internal Pair Creation.                                                                                | 20           |
| <b>Unit II</b>           | <b>Radiation Detectors and Nuclear Models:</b> Detectors: GM tubes, NaI(Tl) Scintillation Detector, Si (Li) and Ge (Li) Detectors, High Purity Germanium Detector, Bubble Chamber, Cloud Chamber, Spark Chamber, Nuclear Models: Shell Model- Square Well Potential, Harmonic Oscillator Potential, Spin-Orbit Coupling, Predictions of the Shell Model, Achievements & Failures of shell Model, Fermi Gas Model, Collective Model.                                                                                                                                                                                                                                                                                                                                                                              | 15           |
| <b>Unit III</b>          | <b>Reaction Dynamics, Nuclear Reactors and Accelerators:</b> Reaction Dynamics: Types of Nuclear Reactions, Conservation Laws in Nuclear Reactions, Q of Nuclear Reaction, Compound Nucleus Hypothesis, Reactors: Fission Chain Reaction, Four Factor Formula, Multiplication Factor, General Properties and Concepts of Nuclear Reactors, Reactor Materials, Types of Reactors, List of Different Types of Reactors Developed in India, Accelerators: Van de Graff, Microtron, Electron & Proton Synchrotron, Pelletron, Cyclotron.                                                                                                                                                                                                                                                                             | 15           |
| <b>Unit IV</b>           | <b>Nuclear Interactions and Particle Physics:</b> Nuclear Interactions: Low Energy Neutron-Proton Scattering, Scattering Length, Spin Dependence of n-p Interaction, Proton-Proton and Neutron-Neutron Scattering at Low Energies, Particle Physics: Classification of Elementary Particles, Mass Spectra and Decays of Elementary Particles- Leptons & Hadrons, Quantum Numbers, Conservation Laws, Quarks.                                                                                                                                                                                                                                                                                                                                                                                                     | 10           |
| <b>References</b>        | <ul style="list-style-type: none"> <li>Kenneth S. Krane (2008). Introductory nuclear Physics, Wiley India Pvt. Ltd.</li> <li>Bernard L. Cohen (1998). Concepts of nuclear physics, Tata Mcgraw Hill.</li> <li>Dunlap R.A. (2004). Introduction to the physics of nuclei &amp; particles, Thomson Asia.</li> <li>Griffith D.\ 1987 Introduction to Elementary Particles, John Wiley &amp; Sons</li> <li>Halzen F., Martin A.D.. 2008 Quarks and Leptons, Wiley India, New Delhi</li> <li>Heyde K. (2004). Basic ideas and concepts in Nuclear Physics - An Introductory Approach, IOP- Institute of Physics Publishing</li> <li>Knoll G.F. (2000). Radiation detection and measurement, John Wiley &amp; Sons.</li> <li>Blatt J.M., Weisskopf V.F. (1991). Theoretical Nuclear Physics, Dover Pub.Inc.</li> </ul> |              |

**MSc II (Physics)**  
**Semester IV**  
**PHY-DSC-622: Experimental Technique in Physics-II**

**Total Hours: 60**

**Credits: 4**

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| <b>Course objectives</b> | <ul style="list-style-type: none"> <li>To understand the various radiation sources, detectors and sensors.</li> <li>To understand about the different types of structural characterization and thermal analysis</li> <li>To impart the adequate knowledge of morphological and magnetic characterization</li> <li>To understand various spectroscopic techniques.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                               |              |
| <b>Course outcomes</b>   | After the completion of this course Students will be able to... <ul style="list-style-type: none"> <li>Understand the various radiation sources, detectors and sensors.</li> <li>Understand about the different types of structural characterization and thermal analysis</li> <li>Know about morphological and magnetic characterization</li> <li>Understand various spectroscopic techniques.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                 |              |
| <b>Unit</b>              | <b>Topic Particular</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Hours</b> |
| <b>Unit I</b>            | <b>Radiation Sources, Detectors and Sensors:</b><br>Sources of Electromagnetic Radiations: Different types of radiations ( $\gamma$ -rays, X- rays, UV-VIS, IR, microwaves and nuclear) and their sources Detectors: $\gamma$ -rays, X-rays, UV-VIS, IR, microwaves and nuclear detectors)<br>Sensors: Sensor's characteristics, Classification of sensors, Operation principles of sensors such as electric, dielectric, acoustic, thermal, optical, mechanical, pressure, IR, UV, gas and humidity with examples                                                                                                                                                                                                                                                         | <b>15</b>    |
| <b>Unit II</b>           | <b>Structural Characterization and Thermal Analysis:</b><br>X-ray Diffraction: Production of X-rays, Types of X-rays (continuous and characteristics), Bragg's diffraction condition, Principle, instrumentation (with filters) and working of X-rays, Techniques used for XRD – Laue's method, Rotating crystal method, Powder (Debye-Scherrer) method, Derivation of Scherrer formula for size determination.<br>Neutron Diffraction: Principle, Instrumentation and Working Thermal analysis: Principle, Instrumentation and Working: Thermo-gravimetric (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC), Graphical analysis affecting various factors. Numericals                                                                  | <b>15</b>    |
| <b>Unit III</b>          | <b>Morphological and Magnetic Characterization:</b><br><b>Optical Microscopy:</b> Principle, Instrumentation and Working of optical microscope<br>Electron Microscopy: Principle, Instrumentation and Working of Scanning Electron Microscope (SEM), Field Emission Scanning Electron Microscope (FESEM) – Advantages over SEM, Transmission Electron Microscope (TEM), Selected Area Electron Diffraction (SAED)<br><b>Probe Microscopy:</b> Principle, Instrumentation and Working of Scanning Tunneling Microscope (STM) and Atomic Force Microscope (AFM)<br>Magnetic Characterization: Principle, Instrumentation and Working of Vibrating Sample Magnetometer (VSM), Analysis of Hysteresis loop, SQUID Technique: Principle, Instrumentation and Working. Numerical | <b>15</b>    |
| <b>Unit IV</b>           | <b>Spectroscopic Analysis:</b><br>Spectroscopic characterization (principle, instrumentation and working): Infra-Red (IR), Fourier Transform Infra-Red (FTIR), Ultraviolet-Visible (UV-VIS), Diffuse, Reflectance Spectroscopy (DRS), X-ray Absorption (XPS), Electron Spin Resonance (ESR), Nuclear Magnetic Resonance (NMR). Numerical                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>15</b>    |
| <b>References</b>        | <ul style="list-style-type: none"> <li>Kapoor S.S., Ramamurthy, V. S., Nuclear Radiation Detectors, Wiley-Eastern Limited, Bombay.</li> <li>Rangan, C.S., Sarma, G.R. and Mani, V.S.V., Instrumentation: Devices and Systems, Tata Mc Graw Hill Publishing Co. Ltd.</li> <li>Chatwal, G. and Anand, S., Instrumental Methods of Chemical Analysis, Himalaya</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                     |              |

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|  | <p>Publishing House.</p> <ul style="list-style-type: none"> <li>• Willard, H.H. Merritt, L.L. and Dean, J.A., Instrumental Methods of Analysis, CBS Publishers</li> <li>• Wachtman, John B. &amp; Kalman, Zwi. H., (1992), Characterization of Materials, Pub. Butterworth Heinemann</li> <li>• Cullity, B. D. and Stock, S. R., (2001), Elements of X-ray diffraction, Printice Hall, - Science - 664 pages.</li> </ul> |  |
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**MSc II (Physics)**  
**Semester IV**  
**PHY-DSE-623A: Electronics Instrumentation**

**Total Hours: 30**

**Credits: 2**

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |              |
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| <b>Course objectives</b> | <ul style="list-style-type: none"> <li>To impart knowledge of electronic instrumentation.</li> <li>To understand the components of electronics instruments.</li> <li>To provide knowledge of bio electrical signal and system.</li> <li>To understand the basic operational Electronics Instrumentation.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |              |
| <b>Course outcomes</b>   | <p>After the completion of this course Students will be able to....</p> <ul style="list-style-type: none"> <li>Understand electrical signal and its processing.</li> <li>Understand the bio electrical signal and system</li> <li>Handle the electronics instrumentation.</li> <li>Apply the knowledge in real life problems.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                             |              |
| <b>Unit</b>              | <b>Topic Particular</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Hours</b> |
| <b>Unit I</b>            | <b>Electrical signals representation and processing:</b><br>Periodic signals, Generation of sine, Square, triangular, linear ramp & saw tooth waveforms. modulated signals (A.M., F.M., P.M.), sampled data pulse Modulation (PWM, PAM, PPM), definition and their graphical representation. Instrumentation amplifier and Filters.                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>4</b>     |
| <b>Unit II</b>           | <b>Bio-electric Signals and Electrodes:</b><br>Basic Physics of membrane potential, resting membrane potential of nerves, nerve action potential, origin of bio-electric signals, recording electrodes, polarization, skin contact impedance, electrodes for ECG, electrodes for EEG, electrical conductivity of electrodes jellies and creams, microelectrodes.                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>8</b>     |
| <b>Unit III</b>          | <b>Telemetry System:</b><br>Multiplexer: Analog & digital multiplexer, Sample and hold Circuit, Data transmission system, Telemetry system, Block diagram, Characteristics, Land line Telemetry, Radio telemetry, Processing system.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>8</b>     |
| <b>Unit IV</b>           | <b>Applications of electronic system:</b><br>Frequency selective wave analyzer, Spectrum analyzer, Lock-in amplifier, Fiber optic sensors. Measurement of Humidity, Hygrometers, Measurement of pH, Measurement of thermal Conductivity (gas analyzer), Flow meters: Classification, working principle: electromagnetic flow meter, Ultrasonic flow meter.                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>10</b>    |
| <b>References</b>        | <ul style="list-style-type: none"> <li>Murthy, D.V.S. (2008). Transducers&amp; Instrumentation. Prentice Hall India Learning Private Limited (2nd ed).</li> <li>Rangan. C.S, Sharma, G.R, &amp; Mani, V.S.V. (2017). Instrumentation-Devices &amp; system. McGraw Hill Education (2nd ed).</li> <li>Morris, A.S. (2001). Principles of Measurement and Instrumentation. Butterworth-Heinemann (3rd ed).</li> <li>Kalsi. H.S. (2017). Electronic Instrumentation. McGraw Hill Education (3rd ed).</li> <li>Sawheny. A.K. (2015). A course in Electrical &amp; electronic measurement Instrumentation. Dhanpat Rai &amp; Co.</li> <li>Helfrick, A.D. &amp; Cooper, W.D. (1992). Modern electronic instrumentation &amp; measurement Technique. Prentice Hall India Learning Private Limited</li> </ul> |              |

**MSc II (Physics)**  
**Semester IV**  
**PHY-DSE-623B: Thin Film Physics**

**Total Hours: 30**

**Credits: 2**

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| <b>Course objectives</b> | <ul style="list-style-type: none"> <li>To study the classification of materials along with their properties &amp; versatile applications in the form of thin film.</li> <li>To develop thin films using various synthesis methods and parameters.</li> <li>To understand importance of advanced development using thin film devices.</li> <li>To nurture a tendency to study &amp; develop different thin film devices for different applications.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                      |              |
| <b>Course outcomes</b>   | After the completion of this course Students will be able to.... <ul style="list-style-type: none"> <li>Student able to apply knowledge of thin film synthesis to fabricate devices.</li> <li>Students would able to work out on scientific temperament.</li> <li>Student may synthesize thin films and develop devices.</li> <li>Knowledge of this field will be able to create an employability.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                      |              |
| <b>Unit</b>              | <b>Topic Particular</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Hours</b> |
| <b>Unit I</b>            | <b>Thin film Growth &amp; theory:</b> metal colloids, nanoclusters, carbon nanotubes, nanocrystalline materials, oxide nanoparticles, Preparation of quantum nanostructures (quantum wells, quantum wires and quantum dots), Theory of thin film nucleation-Impingement, adsorption and thermal accommodation, The capillarity model, Atomistic model, Four stages of thin film growth, cluster coalescence and depletion, Lithography: photo, X-ray and e-beam.                                                                                                                                                                                                                                                                                                                                                                                   | <b>06</b>    |
| <b>Unit II</b>           | <b>Deposition Techniques &amp; Thickness Measurements of Thin Films</b><br><b>Physical Methods:</b> Vacuum evaporation: – Thickness distribution of evaporated films (Point and Ring sources) - Resistive heating, Electron beam evaporation, Co-evaporation Pulsed laser ablation –Epitaxial thin deposition. Sputtering:<br><b>Chemical methods:</b> Electroplating – Spray pyrolysis – Chemical vapour deposition (CVD), Sol-gel – spin coating. Thickness measurement: Multiple beam interferometer (MBI) methods, Quartz crystal thickness monitor, Stylus profiler, Stress measurement by optical method, Gravimetric method.                                                                                                                                                                                                                | <b>08</b>    |
| <b>Unit III</b>          | <b>Classification of thin film characterization techniques:</b> X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), Low energy electron diffraction (LEED), Reflection high energy electron diffraction (RHEED), Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS), RBS (Rutherford back scattering), SIMS (Secondary ion mass spectrometry), Applications: thin film solar cells, Micro-electromechanical systems (MEMS) and Nano-electromechanical systems (NEMS).                                                                                                                                                                                                                                                                                                                                              | <b>07</b>    |
| <b>Unit IV</b>           | <b>Properties &amp; Emerging Applications of Thin Films</b><br>Electrical Properties: Influence of thickness on the resistivity of thin films, Hall Effect in thin films, Fuch-Sondhemir theory, TCR and its effects. Mechanical properties: Adhesion & its measurement with mechanical and nucleation methods, stress measurement by using optical method. Optical properties: Properties of Optical Film Materials, Thin Film Optics, Multilayer Optical Film, Applications. Antireflection Coatings, Multilayer Films, Interference Filters, Polarizers. Patterning techniques (Photolithography), Junction devices (Diodes, Transistors, Solar cells), ICs, Thin film sensors (gas and humidity), Thin films for information storage (Magnetic and optical recording), Metallurgical applications, Photo thermal converters, Optical coatings. | <b>09</b>    |
| <b>References</b>        | <ul style="list-style-type: none"> <li>L. I. Maissel and R. Glang (1970) Hand book of Thin Film Technology: Mc Graw Hill Book Co., 07-039742-2</li> <li>K. L. Chopra (1969) Thin Film Phenomena, Mc Graw Hill Book Co.</li> <li>Material Science of Thin Films Academic Press, 1992, ISBN: 0-12-524990-X</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |              |

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|  | <ul style="list-style-type: none"> <li>• M. Ohring, (1978) Thin Film Process: J. L. Vossen and Kern, Academic Press,</li> <li>• K. L. Chopra, Thin Film Phenomena (McGraw-Hill).</li> <li>• Dieter K. Schroder, (1990) Semiconductor material and DevicesCharacterization, John Wiley and Sons, NY.</li> <li>• V.S. Muralidharan and A. Subramania Nano-science and Technology (Ane Book Pvt. Ltd.).</li> <li>• Charles P. Poole, and Frank J. Owens Introduction to Nanotechnology (Wiley India Pvt. Ltd).</li> <li>• L.I. Maissel and R. Glang, Handbook of thin film technology (McGraw-Hill).</li> </ul> |  |
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**MSc II (Physics)**  
**Semester IV**  
**PHY-DSC-624: Practicals on Nuclear Physics**

**Total Hours: 60**

**Credits: 2**

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| <b>Course objectives</b> | <ul style="list-style-type: none"> <li>To understand the principles of radiation detection and interaction of radiation with matter.</li> <li>To develop skills in experimental techniques for measuring radiation properties and parameters and gain hands-on experience with various types of radiation detectors and associated instrumentation.</li> <li>Explore concepts of nuclear physics, such as Compton scattering, binding energy, and absorption coefficients.</li> <li>Understand the principles behind coincidence techniques and activation methods for measuring radiation and gain practical knowledge of electronic circuits and components used in radiation detection systems.</li> </ul>                                                                                                                                        |              |
| <b>Course outcomes</b>   | <p>After the completion of this course Students will be able to....</p> <ul style="list-style-type: none"> <li>Demonstrate competence in experimental techniques for radiation detection and measurement and analyze experimental data to determine properties such as energy resolution, efficiency, and activity of radiation sources.</li> <li>Apply and communicate experimental procedures, results, and conclusions effectively through written reports and presentations.</li> <li>theoretical knowledge of nuclear physics to interpret experimental results and phenomena.</li> <li>Understand the significance of radiation detection and measurement in various fields such as nuclear physics, health physics, and environmental monitoring and develop skills in troubleshooting and optimizing radiation detection systems.</li> </ul> |              |
| <b>Sr. No.</b>           | <b>Topic Particular</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Hours</b> |
| 1                        | To determine resolving/dead time of a GM counter by double source method.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 4            |
| 2                        | To study Compton scattering using 6.66% MeV gamma-rays.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 4            |
| 3                        | To determine energy resolution of a NaI(Tl) detector and show that it is independent of the gain of the amplifier.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 4            |
| 4                        | To determine energy of a given gamma-ray source by calibration method.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 4            |
| 5                        | To study various operations of 1024 channel analyzer and to calculate energy resolution, energy of gamma ray, area under photopeak etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 4            |
| 6                        | To study beta-ray spectrum of Cs-137 source and to calculate binding energy of K-shell electron of Cs-137. (Required a binding Magnetic )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 4            |
| 7                        | To determine and compare the linear absorption coefficient of gamma radiation for different metals.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 4            |
| 8                        | To determine the efficiency of GM counter detector for different energy gamma radiations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 4            |
| 9                        | To determine the efficiency of GM counter for beta particles.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 4            |
| 10                       | To make a short-lived isotope using thermal/fast neutrons and measure its half life time. (Neutron Sources Required)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 4            |
| 11                       | To determine resolving time of a coincidence using chance coincidence technique                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 4            |

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| <b>12</b>         | To determine activity of a given gamma-ray source using radiation monitor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 4 |
| <b>13</b>         | Measurement of neutron flux using activation method. (Accelerator required for activation analysis)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 4 |
| <b>14</b>         | To measure efficiency of a NaI(Tl) detector.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 4 |
| <b>15</b>         | To measure energy resolution of a NaI(Tl) detector.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 4 |
| <b>16</b>         | To study the pulse shaping circuits for nuclear electronics. Verify the different networks and trace out the respective shapes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 4 |
| <b>References</b> | <ul style="list-style-type: none"> <li>• Nuclear radiation detectors, S. S. Kapoor and V. S. Ramanurthy. (Wiley Eastern Limited, New Delhi,) 1986.</li> <li>• Introduction to radiation protection dosimetry, J. Sabol and P. S. Weng, (World Scientific), 1995.</li> <li>• Techniques for nuclear and particle physics, W. R. Len (Springer), 1955.</li> <li>• Nuclear Measurement Techniques, K. Sriram, (Affiliated East-West Press, New Delhi), 1986.</li> <li>• Introduction to nuclear science and technology, K. Sriram and Y. R. Waghmare, (A. M. Wheeler), 1991.</li> <li>• Nuclear radiation detection, W. J. Price, (McGraw-Hill, New York), 1964.</li> <li>• Alphas, beta and gamma-ray spectroscopy,. K. Siegbahn, (North Holland, Amsterdam), 1965.</li> <li>• Introduction to experimental nuclear physics, R. M. Singru, (John Wiley and Sons), 1974.</li> <li>• Radioactive isotopes in biological research, Willaim R. Hendee, (John Wiley and Sons), 1973.</li> <li>• Atomic and Nuclear physics, Satendra Sharma, Pearson Education, 2008</li> </ul> |   |

**MSc II (Physics)**  
**Semester IV**  
**PHY-DSC-625: Practicals on Experimental Techniques in Physics-II**

**Total Hours: 60**

**Credits: 2**

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| <b>Course Objectives</b> | <ul style="list-style-type: none"> <li>To develop the students practical and technical skills required for physics experimentation.</li> <li>To develops students logical thinking, skill for collecting, Analysis and extracting relevant information from experimental outcomes.</li> <li>To develops students skill for handling sophisticated and sensitive instrumentation.</li> <li>To impart the adequate knowledge of various detectors, sensors, spectroscopic analysis, thermal analysis and morphological and magnetic analysis of materials</li> </ul>                                              |              |
| <b>Course Outcomes</b>   | <p>After the completion of this course Students will be able to....</p> <ul style="list-style-type: none"> <li>To understand and differentiate the Characterization techniques.</li> <li>To understand to do proper selection of particular techniques and its application for data analysis and testing of synthesis material.</li> <li>To understand Practical Skill and Instrument working as well as handling knowledge will help students in their future research carrier and higher studies.</li> <li>To understand the fundamental process of advanced material characterization techniques.</li> </ul> |              |
| <b>Sr. No.</b>           | <b>TopicParticular</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Hours</b> |
| 1                        | Optical absorption of nanoparticles (observation of Blueshift with size of particles).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 4            |
| 2                        | To analyse the photoluminescence spectrum of a given sample.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 4            |
| 3                        | To analyse the Raman Spectrum of a sample.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 4            |
| 4                        | X-ray diffraction studies of nanoparticles (effect of temperature).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 4            |
| 5                        | Determination of crystal structure of given material by X-ray diffract meter.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 4            |
| 6                        | Determination of grain size of a given sample by Scherer method.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 4            |
| 7                        | Determination of direct and indirect band gap of a given materials by UV-visible spectroscopy.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 4            |
| 8                        | Determination of inter atomic bond length in a diatomic molecule by studying rotational vibrational IR spectra.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 4            |
| 9                        | Study of Beer Lamberts Law in absorption spectroscopy using IR spectroscopy.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 4            |
| 10                       | Stress measurement of transparent conducting oxides (Newton's ring method).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 4            |
| 11                       | Determination of refractive index of a transparent film by Abe's method.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 4            |
| 12                       | Determination of Electrical conductivity measurements in thick films.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 4            |
| 13                       | Determine the thickness of thick film by gravimetric method.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 4            |
| 14                       | Determine weight loss of given sample using thermo gravimetric analysis.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 4            |
| 15                       | To determine the enthalpy of fusion and crystallization of given sample using DSC data.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4            |
| 16                       | Identify the functional group of a given sample using FTIR.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 4            |

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| <b>17</b>         | To Analyze the data of SEM for a given sample.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 4 |
| <b>18</b>         | Analysis of hysteresis loop.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 4 |
| <b>References</b> | <ul style="list-style-type: none"> <li>• Kapoor S.S., Ramamurthy, V. S., Nuclear Radiation Detectors, Wiley-Eastern Limited, Bombay.</li> <li>• Rangan, C.S., Sarma, G.R. and Mani, V.S.V., Instrumentation: Devices and Systems, Tata Mc Graw Hill Publishing Co. Ltd.</li> <li>• Chatwal, G. and Anand, S., Instrumental Methods of Chemical Analysis, Himalaya Publishing House.</li> <li>• Willard, H.H. Merritt, L.L. and Dean, J.A., Instrumental Methods of Analysis, CBS Publishers</li> <li>• Wachtman, John B. &amp; Kalman, Zwi. H., (1992), Characterization of Materials, Pub. Butterworth Heinemann</li> <li>• Cullity, B. D. and Stock, S. R., (2001), Elements of X-ray diffraction, Printice Hall, - Science - 664 pages.</li> </ul> |   |

**MSc II (Physics)**  
**Semester IV**  
**PHY-DSE-626A: Practical on Electronics Instrumentation**

**Total Hours: 60**

**Credits: 2**

|                          |                                                                                                                                                                                                                                                                                                                                  |              |
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| <b>Course objectives</b> | <ul style="list-style-type: none"> <li>To impart knowledge of electronic instrumentation.</li> <li>To understand the components of electronics instruments.</li> <li>To provide knowledge of bio electrical signal and system.</li> <li>To understand the basic operational Electronics Instrumentation.</li> </ul>              |              |
| <b>Course outcomes</b>   | After the completion of this course Students will be able to... <ul style="list-style-type: none"> <li>Understand electrical signal and its processing.</li> <li>Understand the bio electrical signal and system</li> <li>Handle the electronics instrumentation.</li> <li>Apply the knowledge in real life problems.</li> </ul> |              |
| <b>Sr. No.</b>           | <b>Topic Particular</b>                                                                                                                                                                                                                                                                                                          | <b>Hours</b> |
| <b>1</b>                 | Design, built and test Square and Triangular wave generator.                                                                                                                                                                                                                                                                     | 4            |
| <b>2</b>                 | Design, Built and test saw tooth generator.                                                                                                                                                                                                                                                                                      | 4            |
| <b>3</b>                 | Built and test AM wave generator (Amplitude Modulator).                                                                                                                                                                                                                                                                          | 4            |
| <b>4</b>                 | Built and test FM wave generator (Frequency Modulator).                                                                                                                                                                                                                                                                          | 4            |
| <b>5</b>                 | Design, built and test PAM using IC-555/IC 741.                                                                                                                                                                                                                                                                                  | 4            |
| <b>6</b>                 | Design, built and test PWM using IC-555/IC 741.                                                                                                                                                                                                                                                                                  | 4            |
| <b>7</b>                 | Design, built and test PPM using IC-555/IC 741.                                                                                                                                                                                                                                                                                  | 4            |
| <b>8</b>                 | Built and test Instrumentation amplifier.                                                                                                                                                                                                                                                                                        | 4            |
| <b>9</b>                 | Study of EEG electrode.                                                                                                                                                                                                                                                                                                          | 4            |
| <b>10</b>                | Study of ECG electrode.                                                                                                                                                                                                                                                                                                          | 4            |
| <b>11</b>                | Built and test Analog Multiplexer.                                                                                                                                                                                                                                                                                               | 4            |
| <b>12</b>                | Built and test Digital Multiplexer.                                                                                                                                                                                                                                                                                              | 4            |
| <b>13</b>                | Design, built and test Sample and hold circuit.                                                                                                                                                                                                                                                                                  | 4            |
| <b>14</b>                | Design, built and test Lock in amplifier                                                                                                                                                                                                                                                                                         | 4            |
| <b>15</b>                | Study of fiber optic sensor.                                                                                                                                                                                                                                                                                                     | 4            |
| <b>16</b>                | Study of Measurement of humidity                                                                                                                                                                                                                                                                                                 | 4            |
| <b>17</b>                | Study of Measurement of pH.                                                                                                                                                                                                                                                                                                      | 4            |
| <b>18</b>                | Study of Ultrasonic flow meter.                                                                                                                                                                                                                                                                                                  | 4            |

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| <b>References</b> | <ul style="list-style-type: none"> <li>• Murthy, D.V.S.(2008). Transducers&amp; Instrumentation. Prentice Hall India Learning Private Limited (2nd ed).</li> <li>• Rangan. C.S, Sharma, G.R, &amp; Mani, V.S.V. (2017). Instrumentation-Devices &amp;system. McGraw Hill Education (2nd ed).</li> <li>• Morris, A.S. (2001). Principles of Measurement and Instrumentation. Butterworth-Heinemann (3nd ed).</li> <li>• Kalsi. H.S. (2017). Electronic Instrumentation. McGraw Hill Education (3nd ed).</li> <li>• Sawheny. A.K. (2015). A course in Electrical &amp; electronic measurement Instrumentation. Dhanpat Rai &amp; Co.</li> <li>• Helfrick, A.D. &amp; Cooper, W.D. (1992). Modern electronic instrumentation &amp; measurement Technique. Prentice Hall India Learning Private Limited.</li> <li>• Khandpur, R.S. (2014). Handbook of Bio-medical Instrumentation. McGraw Hill Education (3nd ed).</li> </ul> |  |
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**MSc II (Physics)**  
**Semester IV**  
**PHY-DSE-626B: Practicals on Thin Film Physics**

**Total Hours: 60**

**Credits: 2**

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| <b>Course objectives</b> | <ul style="list-style-type: none"> <li>To develop the practical knowledge amongst the PG about thin film fabrication techniques.</li> <li>To expertise with experimental handling.</li> <li>To learn and adopt thin film fabrication and its application.</li> <li>To spread an importance of thin film in sustainability.</li> </ul>                                                                                                                                                                                                                             |              |
| <b>Course outcomes</b>   | After the completion of this course Students will be able to.... <ul style="list-style-type: none"> <li>Students will able to understand the importance of thin film.</li> <li>Students will able to use vacuum system.</li> <li>impart the knowledge in society to solve real time issues.</li> <li>Able to expand and explore the depth of understanding.</li> </ul>                                                                                                                                                                                            |              |
| <b>Sr. No.</b>           | <b>TopicParticular</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Hours</b> |
| 1                        | Study the temperature dependence of thermo emf of a semiconductor thin film.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 4            |
| 2                        | To measure resistivity and activation energy of thin film using 'Two Probe Method'                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 4            |
| 3                        | Determination of optical energy band gap of a semiconductor using transmission measurements.                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 4            |
| 4                        | Hall effect – determination of carrier mobility and concentration in a semiconductor film                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4            |
| 5                        | Study the current-voltage characteristics of a solar cell.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 4            |
| 6                        | To determine optical constants of thin films using transmittance data                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 4            |
| 7                        | To deposit thin film of Metal chalcogenide material using chemical method                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4            |
| 8                        | To deposit thin film of TiO <sub>2</sub> using doctor blade method                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 4            |
| 9                        | To study the UV-Vis spectra of ZnO thin film and determine the band gap.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 4            |
| 10                       | To study the switching in band gap of thin film using optimized reaction parameters.                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 4            |
| 11                       | To determine particle size of CdS thin film using X-ray spectra.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 4            |
| 12                       | To interpret and calculate interplanar distance using given data.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 4            |
| 13                       | Determination of thickness of thin film using Tolansky's technique                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 4            |
| 14                       | To fabricate the junction and use as humidity sensor.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 4            |
| 15                       | To check and study the diode characteristic of synthesized thin film junction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 4            |
| 16                       | To determine polymer degradation of thin film using photocatalysis process.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 4            |
| References               | <ul style="list-style-type: none"> <li>Analytical Techniques for Thin Film-Treatise on Material Science and Technology, Vol. 27: K.N. Tu and R. Rosenberg (ed.).</li> <li>M. Ohring, (1992) The Materials Science of Thin Films, Academic Press, New York.</li> <li>L.I. Maissel and R.L. Glang, (1970) Handbook of Thin Film Technology, Mc Graw Hill Book Co.</li> <li>B. R. Sankapal, A. Ennaoui, R. B. Gupta, C. D. Lonkhande-Editors Simple Chemical Methods for Thin Film Deposition-Synthesis &amp; Applications, (2023) ISBN 978-981-99-0960-5</li> </ul> |              |

**MSc II (Physics)**  
**Semester IV**  
**PHY-RP-627: Research Project-II**

**Total Hours: 180**

**Credit: 6**

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| <b>Course objectives</b> | <ul style="list-style-type: none"> <li>To give exposure to the students to research culture and technology</li> <li>To introduce students to how to select a research topic, plan, perform experiments, collect data and analyze the data</li> <li>To foster self-confidence and self-reliance in the students as they learn to work and think independently</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |              |
| <b>Course outcomes</b>   | <p>After the completion of this course Students will be able to....</p> <ul style="list-style-type: none"> <li>Conceive a problem based on published research and conduct a comprehensive literature survey.</li> <li>Plan and carry out the tasks in the given framework of the dissertation and present the work in writing and viva.</li> <li>Learn handling of instruments, use of chemicals and how to conduct the experiments</li> <li>Learn how to present the project in PowerPoint and answer the queries to examiners and the science of writing.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |              |
| <b>Sr. No.</b>           | <b>Topic Particular</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Hours</b> |
| <b>1</b>                 | <p><b>The systematic approach towards the execution of the project should be as follows: (Wherever applicable)</b></p> <ol style="list-style-type: none"> <li>The complete tenure of the research project should be one academic year. It should be allotted during the third semester and completed in the fourth semester.</li> <li>Weekly 12 hours should be allotted to the research project in a regular timetable.</li> <li>In the fourth semester, students should perform further experimental work, analyze the data and compile the results.</li> <li>Students may be given an opportunity to participate in ongoing research activities in the respective Departments/Schools/Supervisors' laboratories. This will familiarize them with the literature survey and give them a fundamental understanding of designing and executing a research project.</li> <li>Students may work individually or in groups (not more than 3 students) to be decided by the concerned department/supervisor.</li> <li>Each research group should have a different research topic with some possible level of novelty.</li> <li>The student should select the topic relevant to priority areas of concern or allied subjects.</li> <li>Students are encouraged to work on multidisciplinary and applied projects, but it is not mandatory criteria.</li> <li>Students are expected to work in line with the research outline and literature review, which was submitted in the third semester.</li> <li>Students are expected to learn how to execute the research work systematically and overcome the hurdles. Students will get the opportunity to learn about practical aspects of many characterization techniques or models and further how to effectively employ them in the research work. Students should be able to critically evaluate the literature on the topic, identify the research gaps, plan and perform the experiments, interpret the results, understand the limitations of the work and draw conclusions.</li> <li>At the end of the semester, each student should submit a detailed Research Report.</li> <li>The format of the final research report shall be as per the guidelines of respective department. (<b>Example:</b> Title of the Project, Certificates, Acknowledgment, Abstract and Keywords, Contents, Introduction, Literature Review, Aim and objective, Materials and Methods, Result, Data analysis and Discussions, conclusion, limitations, suggestion, future scope, Bibliography, Appendix etc.)</li> <li>An appropriate and essential conclusive statement must be drawn at the end of the</li> </ol> |              |

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|  | <p>study.</p> <ol style="list-style-type: none"> <li>14. Students should maintain lab notebooks, and the supervisor may ask them to submit the mid-semester progress report.</li> <li>15. For documents related to project submission: Font- Times New Roman, Heading Font Size-14, Normal Text Size-12, spacing-1.5, both sides justified and 1 inch margin on all side, both side printing on A-4 size.</li> <li>16. Three copies of the dissertation should be prepared (one copy for each department, guide, and student).</li> <li>17. At the end of the semester, the candidate should prepare and present research using a PowerPoint presentation using modern ICT tools during the Internal and External Examination.</li> <li>18. Besides writing a dissertation, students are encouraged to write a manuscript/patent if the results obtained are worthy of publication.</li> <li>19. Students may present their research work in Avishkar/Webinars/Conferences.</li> <li>20. Students should note that plagiarism is strictly prohibited.</li> </ol> <p><b>Internal examination (60 marks):</b> Components of continuous internal assessment:</p> <ul style="list-style-type: none"> <li>• Literature collected, methodological planning, analysis of data, design and work, progress reports etc (30 marks)</li> <li>• Presentation in Webinars/Conferences/publication and departmental presentationetc (20 marks)</li> <li>• Oral examination (10 marks)</li> </ul> <p><b>External examination (90 marks)</b>and Components of external assessment:</p> <ul style="list-style-type: none"> <li>• Evaluation of dissertation submitted in bound form at the time of examination <b>(60 marks)</b></li> <li>• Presentation (PPT format) <b>(15 marks)</b></li> <li>• Overall presentation reflecting the contribution of work, Response to questions <b>(15 marks)</b></li> </ul> <ol style="list-style-type: none"> <li>4. How much effort was put into the project?</li> <li>5. Was an interim report presented on time?</li> <li>6. Was the students project logbooks adequate?</li> <li>7. How much initiative and/or originality did the student contribute to the project.</li> <li>8. How well did the student cope with problems that arose during the course of project?</li> <li>9. Did a project reach a stage of completion where meaningful results were obtained and definite conclusions could be drawn?</li> </ol> <p><b>(ii) The Project Report:</b></p> <ol style="list-style-type: none"> <li>1. How well did the report set out the background?</li> <li>2. How well did the report describe the underlying them?</li> <li>3. Was the report a reasonable length?</li> <li>4. How well was the report structured?</li> <li>5. How understandable was the written content?</li> <li>6. How well did the report describe the execution of the project?</li> <li>7. Did the report have an adequate summary or conclusions?</li> </ol> <p><b>(iii) Oral Examination:</b></p> <ol style="list-style-type: none"> <li>1. Did the student adequately describe what he/she had done in their project?</li> <li>2. Did the student have a clear interpretation of his/her results?</li> <li>3. What was the clarity and overall standard of the presentation?</li> <li>4. How well was the talk/presentation structured?</li> <li>5. Did the student cover all the relevant material in a reasonable time?</li> </ol> |  |
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