RAMAIAH UNIVERSITY OF APPLIED SCIENCES

# M S Ramaiah University of Applied Sciences

# Programme and Course Specifications
# Of

## M.Sc. (Physics)
## Post Graduate Degree Programme

Batch 2022 onwards

## Programme Code: 104

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M.S. Ramaiah University of Applied Sciences
Bangalore - 560 054

## Department: Physics
## Faculty of Mathematical and Physical Science
## M S Ramaiah University of Applied Sciences

Dean - Academics
M.S. Ramaiah University of Applied Sciences
Bangalore-560054

# University's Vision, Mission and Objectives

The M. S. Ramaiah University of Applied Sciences (MSRUAS) will focus on student-centric professional education and motivates its staff and students to contribute significantly to the growth of technology, science, economy and society through their imaginative, creative and innovative pursuits. Hence, the University has articulated the following vision and objectives.

## Vision

MSRUAS aspires to be the premier university of choice in Asia for student centric professional education and services with a strong focus on applied research whilst maintaining the highest academic and ethical standards in a creative and innovative environment

## Mission

Our purpose is the creation and dissemination of knowledge. We are committed to creativity, innovation and excellence in our teaching and research. We value integrity, quality and teamwork in all our endeavors. We inspire critical thinking, personal development and a passion for lifelong learning. We serve the technical, scientific and economic needs of our Society.

## Objectives

1. To disseminate knowledge and skills through instructions, teaching, training, seminars, workshops and symposia in Engineering and Technology, Art and Design, Management and Commerce, Health and Allied Sciences, Physical and Life Sciences, Arts, Humanities and Social Sciences to equip students and scholars to meet the needs of industries, business and society
2. To generate knowledge through research in Engineering and Technology, Art and Design, Management and Commerce, Health and Allied Sciences, Physical and Life Sciences, Arts, Humanities and Social Sciences to meet the challenges that arise in industry, business and society
3. To promote health, human well-being and provide holistic healthcare
4. To provide technical and scientific solutions to real life problems posed by industry, business and society in Engineering and Technology, Art and Design, Management and Commerce, Health and Allied Sciences, Physical and Life Sciences, Arts, Humanities and Social Sciences
5. To instill the spirit of entrepreneurship in our youth to help create more career opportunities in the society by incubating and nurturing technology product ideas and supporting technology backed business
6. To identify and nurture leadership skills in students and help in the development of our future leaders to enrich the society we live in
7. To develop partnership with universities, industries, businesses, research establishments, NGOs, international organizations, governmental organizations in India and abroad to enrich the experiences of faculties and students through research and developmental programmes

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Approved by the Academic Council at its 26th meeting held on 14 July 2022

## Programme Specifications: B. Sc. Hons (Chemistry)

| | |
|---|---|
| **Faculty** | Mathematical and Physical Sciences |
| **Department** | Physics |
| **Programme Code** | 104 |
| **Programme Name** | M.Sc. Physics |
| **Dean of the Faculty** | Dr. Dilip Kumar Mahanty |
| **Head of the Department** | Dr. Premakumar H.B. |

1. **Title of the Award:** M.Sc. Physics
2. **Mode of Study:** Full-Time
3. **Awarding Institution /Body:** M. S. Ramaiah University of Applied Sciences, Bengaluru
4. **Joint Award:** Not Applicable
5. **Teaching Institution:** Faculty of Mathematical and Physical Sciences, M. S. Ramaiah University of Applied Sciences, Bengaluru
6. **Date of Programme Specifications:** 14th July 2022
7. **Date of Programme Approval by the Academic Council of MSRUAS:** 14th July 2022
8. **Next Review Date:** July 2024
9. **Programme Approving Regulating Body and Date of Approval:** University Grants Commission, New Delhi, 21 July 2016
10. **Programme Accredited Body and Date of Accreditation:** Not Applicable
11. **Grade Awarded by the Accreditation Body:** Not Applicable
12. **Programme Accreditation Validity:** Not Applicable
13. **Programme Benchmark:** Not Applicable
14. **Rationale for the Programme**

Physics investigates the laws of nature and is indispensable not only for our understanding of the world but also for the solution of the technological and ecological problems. As a fundamental science, physics continues to be the driving intellectual force in expanding our understanding of the universe, in discovering the scientific basis for new technologies, and in applying these technologies to research.

The Master of Science degree in Physics is traditionally taken by students interested in a career in physics research in government or industry, or in college- and university-level teaching and research.

In our country, teaching/research in physics is being carried out in a number of universities and CSIR / Defense laboratories. There are also plenty of opportunities for pursuing doctoral programs in US/Europe. physics forms an important component of undergraduate programmes both in engineering and basic sciences. After nearly two decades of IT revolution and its booming economic impact on the country, there is a positive trend and appreciation for the role and importance of basic sciences for further technological advancement. There is a need for qualified



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and competent post graduate students with sound knowledge in Physics.

M.Sc. Physics programme offers two specializations, Applied Solid State Physics and Nuclear Physics and Technology.

Solid state physics has tremendous impact on the technological changes in the past 70 years. With the discovery of transistor in the early 1950's, semiconductor industry has paved the way for the advent of microelectronics, minicomputers and information technology. Semiconductor lasers and laser amplifiers have revolutionised optical communication. Solid State Physics has also contributed to the design of important technological materials, which have found applications in sensor technology, MEMS and MOEMS. It has become imperative for physicists to get involved in solving the practical problems faced by engineers. A firm foundation of the basic principles of solid-state physics and practical knowledge of the solid-state devices has become an absolute necessity.

The energy consumption all over the world has been increasing and nuclear energy is still one of the best options as a viable source of energy. Though there are concerns about safety and nuclear waste management, nuclear energy is there to stay in the immediate future. Nuclear medicine has been successfully deployed especially in the treatment of cancer and this also opens up several job opportunities for nuclear physicists.

The Faculty of Mathematical and Physical Sciences of RUAS offers the M.Sc. Physics programme with an outcome-based curriculum emphasizing the Critical, Analytical and Problem-Solving skills to equip the students to pursue their scientific and research career with better preparedness and matured professional outlook. The presence of other allied Faculties of the University provides additional exposure to students the multi-disciplinary approach which is emerging as a key differentiator in the success of modern scientific and engineering endeavors.

## 15. Programme Mission

The purpose of the programme is to train post graduates with advanced knowledge and understanding of Physics with higher order critical, analytical, problem solving and research skills; ability to think rigorously and independently to meet higher level expectations of academia, business and research with sufficient transferrable skills.

## 16. Gradate Attributes (GAs)

**GA 1.** Ability to apply fundamental knowledge of Mathematical and Physical Sciences to solve real life problems in their chosen domain

**GA 2.** Ability to teach in schools, colleges and universities with relevant training and perform administrative duties in government, semi-government, private and public sector organizations

**GA 3.** Ability to understand and solve scientific problems by conducting experimental investigations

**GA 4.** Ability to apply appropriate tools, techniques and understand utilization of resources appropriately in various laboratories

**GA 5.** Ability to conduct scientific research and disseminate the knowledge in the chosen domain

**GA 6.** Ability to understand the effect of scientific solutions on legal, cultural, social, public health and safety aspects, and apply ethical principles to scientific practices and professional responsibilities

**GA 7.** Ability to develop sustainable solutions and understand their effect on society and environment



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**GA 8.** Ability to Ability to work as a member of a team, to plan and to integrate knowledge of various disciplines and to lead teams in multidisciplinary settings

**GA 9.** Ability to make effective oral presentations and communicate technical ideas to a broad audience using written and oral means

**GA 10.** Ability to adapt to the changes and advancements in science and engage in independent and life-long learning

**Programme Outcomes (POs)**

M.Sc. Physics post graduates will be able to:

PO 1. **Scientific Knowledge:** Apply fundamental knowledge of Physics to solve real life problems in their chosen domain

PO 2. **Knowledge, Dissemination and Administration:** disseminate knowledge in educational institutions with relevant training and perform administrative duties in government, semi-government, private and public sector organizations

PO 3. **Problem Solving:** Understand and solve scientific problems by conducting experimental investigations

PO 4. **Modern Tool Usage:** Apply appropriate tools, techniques and understand utilization of resources appropriately in various laboratories

PO 5. **Research:** Conduct scientific research and disseminate the knowledge in the chosen domain

PO 6. **The Science, Society and Ethics:** Understand the effect of scientific solutions on legal, cultural, social, public health and safety aspects, and apply ethical principles to scientific practices and professional responsibilities

PO 7. **Environment and sustainability:** Develop sustainable solutions and understand their effect on society and environment

PO 8. **Individual and teamwork:** Work as a member of a team, to plan and to integrate knowledge of various disciplines as individual and to lead teams in multidisciplinary settings

PO 9. **Communication:** Make effective oral presentations and communicate technical ideas to a broad audience using written and oral means

PO 10. **Life-long learning:** Adapt to the changes and advancements in science and engage in independent and life-long learning

## 17. Programme Goal

The programme goal is to produce post graduates having critical, analytical and problem-solving skills, and ability to think independently, and to pursue a career in academia with further relevant training, business and industry.

## 18. Program Educational Objectives (PEOs)

The educational objectives of the M.Sc. Physics Programme are to:

**PEO-1.** Provide students a fundamental knowledge in physics to enable them to deliver efficient solutions for complex Scientific problems using analytical and cognitive skills in their chosen domain.

**PEO-2.** Enable students to apply appropriate tools, techniques, methods and understand utilization of resources in laboratories and computational skills in their chosen domain and work as an individual as well as lead team in multidisciplinary settings.



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**PEO-3.** Inculcate ethics, environmental sustainability, communication, soft, managerial and entrepreneurial skills for a successful career in the chosen profession and to engage in lifelong learning and also work towards developing sustainable society.

**Programme Specific Outcomes (PSOs)**

At the end of the M.Sc. Physics program, the graduate will be able to:

**PSO-1.** Apply the concepts and laws of Physics to solve scientific problems, model, simulate and interpret the results of physical systems.

**PSO-2.** To enhance the capabilities of students to take up research and perform duties as per scientific protocols in their chosen domains in academics, research institutes and industry as an individual, and as a leader.

**PSO-3.** Demonstrate ethics, leadership qualities, communication, entrepreneurial skills and involvement in lifelong learning for the betterment of organization, environment and society.

**19. Programme Structure:**

| Semester 1 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sl. No.** | **Course Code** | **Course Title** | **Theory (h/W/S)** | **Tutorials (h/W/S)** | **Practical (h/W/S)** | **Max. Marks** | **Total Credits** |
| 1 | PYC511A | Mathematical Methods of Physics | 3 | 1 | 0 | 100 | 4 |
| 2 | PYC512A | Classical Mechanics | 3 | 1 | 0 | 100 | 4 |
| 3 | PYC513A | Quantum Mechanics - 1 | 3 | 1 | 0 | 100 | 4 |
| 4 | PYC514A | Electronics and devices and Laboratory | 3 | 1 | 2 | 100 | 5 |
| 5 | PYL515A | General Physics Laboratory | 0 | 0 | 4 | 50 | 2 |
| 6 | PYL516A | Matlab | 0 | 0 | 2 | 50 | 1 |
| | | **Total** | **12** | **04** | **08** | **500** | **20** |

| Semester 2 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sl. No.** | **Course Code** | **Course Title** | **Theory (h/W/S)** | **Tutorials (h/W/S)** | **Practical (h/W/S)** | **Max. Marks** | **Total Credits** |
| 1 | PYC521A | Electrodynamics | 3 | 1 | 0 | 100 | 4 |
| 2 | PYC522A | Statistical Mechanics and Thermodynamics | 3 | 1 | 0 | 100 | 4 |
| 3 | PYC523A | Atomic and Molecular Physics and Laboratory | 3 | 1 | 2 | 100 | 5 |
| 4 | PYC524A | Solid State Physics | 3 | 1 | 0 | 100 | 4 |
| 5 | PYL525A | Python Laboratory | 1 | 0 | 2 | 50 | 2 |
| 6 | PYS526A | Seminar 1 | 0 | 0 | 2 | 50 | 1 |
| | | **Total** | **13** | **04** | **06** | **500** | **20** |



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| Semester 3 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sl. No. | Course Code | Course Title | Theory (h/W/S) | Tutorials (h/W/S) | Practical (h/W/S) | Max. Marks | Total Credits |
| 1 | PYC611A | Numerical Techniques, Computational Physics and Laboratory | 3 | 1 | 2 | 100 | 5 |
| 2 | PYC612A | Quantum Mechanics - 2 | 3 | 1 | 0 | 100 | 4 |
| 3 | PYC613A | Nuclear and Particle Physics | 3 | 1 | 0 | 100 | 4 |
| 4 | PYC631A | Advanced Solid-State Physics and Laboratory | 3 | 1 | 2 | 100 | 5 |
| 5 | PYC641A | Nuclear Physics, Nuclear Electronics, Applications and Laboratory | | | | | |
| 6 | MPF614A | Research Methodology | 2 | 0 | 0 | 50 | 2 |
| 7 | PYL615A | Advanced Physics Laboratory | 0 | 0 | 4 | 50 | 2 |
| 8 | PYI616A | Internship | 0 | 0 | 2 | 50 | 1 |
| 9 | PYS617A | Seminar-2 | | | | | |
| | | **Total** | **14** | **04** | **10** | **550** | **23** |

| Semester 4 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sl. No. | Course Code | Course Title | Theory (h/W/S) | Tutorials (h/W/S) | Practical (h/W/S) | Max. Marks | Total Credits |
| 1 | PYC632A | Semiconductor Physics | 3 | 1 | 0 | 100 | 4 |
| 2 | PYC642A | Reactor Physics, Shielding and Safety | | | | | |
| 3 | PYI621A | Internship* | 0 | 0 | 6 | 100 | 3 |
| | PYE62XA | Discipline Elective / Open Elective | 3 | 0 | 0 | | |
| 4 | PYP622A | Dissertation | 0 | 0 | 24 | 300 | 12 |
| | | **Total** | **6** | **1** | **30** | **500** | **19** |

**20. Course Delivery:** As per the Timetable

**21. Teaching and Learning Methods**

1. Face to Face Lectures using Audio-Visuals
2. Workshops, Group Discussions, Debates, Presentations
3. Demonstrations
4. Guest Lectures
5. Laboratory work/Fieldwork/Workshop

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6. Industry Visit
7. Seminars
8. Group Exercises
9. Project Work
10. Project
11. Exhibitions
12. Technical Festivals

## 22. Assessment and Grading

### 22.1. Components of Grading

There shall be **two components** of grading in the assessment of each course:

**Component 1, Continuous Evaluation (CE):** This component involves multiple subcomponents (SC1, SC2, etc.) of learning assessment. The assessment of the subcomponents of CE is conducted during the semester at regular intervals. This subcomponent represents the formative assessment of students' learning.

**Component 2, Semester-End Examination (SEE):** This component represents the summative assessment carried out in the form an examination conducted at the end of the semester.

Marks obtained CE and SEE components have equal weightage (CE: 50 % and SEE: 50 %) in determining the final marks obtained by a student in a Course.

The complete details of Grading are given in the Academic Regulations.

### 22.2. Continuous Evaluation and Semester-End Examination Policies

Continuous evaluation and Semester-End Examination depends on the type of the course as discussed below:

#### 22.2.1 Theory Courses

| Theory Course | | | |
|---|---|---|---|
| CE (Weightage: 50 %) | | | SEE (Weightage: 50 %) |
| TSC1 Midterm exam / Term Test | TSC2 Assignment | TSC3 Innovative | SEE Written exam |
| 50 Marks | 25 Marks | 25 Marks | 100 Marks |

There shall be three subcomponents, first one is midterm exam carrying 50 marks and others carrying 25 marks each.
The innovative TSC3 can be of any of the following types:

a) Online Test
b) Problem Solving
c) Field Assignment

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d) Open Book Test
e) Portfolio
f) Reports
g) Case Study
h) Group Task
i) Quiz
j) Any other

After the three subcomponents are evaluated, the CE component marks are determined as:
CE Component Marks = (Total of the marks obtained in all the 3 subcomponents) ÷ 2

**22.2.2 Laboratory Course**

For a laboratory course, the scheme for determining the CE marks is as under:

| Laboratory Course | | |
|---|---|---|
| CE (Weightage: 50 %) | | SEE (Weightage: 50 %) |
| LSC1 | LSC2 | Lab - SEE |
| 25 Marks | 25 Marks | 50 Marks |

The CE subcomponents can be of any of the following types:

a) Laboratory / Clinical Work Record
b) Experiments
c) Computer Simulations
d) Creative Submission
e) Virtual Labs
f) Viva / Oral Exam
g) Lab Manual Report
h) Any other (e.g. combinations)

After the subcomponents of CE are evaluated, the CE component Marks are determined as:

CE Component Marks = (Total of the marks obtained in two subcomponents) ÷ 2

**22.2.3 Course Having a Combination of Theory and Laboratory**

For a course that contains the combination of theory and laboratory sessions, the scheme for determining the CE marks is as under:

| Course with the combination of Theory and Laboratory | | | | | |
|---|---|---|---|---|---|
| CE (Weightage: 50 %) | | | | SEE (Weightage: 50 %) | |
| TSC1: (20 %) Midterm exam / Term Test | TSC2: (10 %) Assignment | TSC3: (10 %) Innovative | LSC4: (10 %) CE | SEE (35 %) Theory | SEE (15 %) Laboratory |
| 50 marks | 25 Marks | 25 Marks | 25 Marks | 100 Marks | 25 Marks |



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There shall be four subcomponents, first one is midterm exam carrying 50 marks and others carrying 25 marks each. The fourth subcomponent shall be set to evaluate the students' performance in the laboratory.

The theory innovative TSC3 can be of any of the following types:

a) Online Test
b) Problem Solving
c) Field Assignment
d) Open Book Test
e) Portfolio
f) Reports
g) Case Study
h) Group Task
i) Quiz
j) Any other

The laboratory sub component LSE4 can be of any of the following types:

a) Laboratory / Clinical Work Record
b) Experiments
c) Computer Simulations
d) Creative Submission
e) Virtual Labs
f) Viva / Oral Exam
g) Lab Manual Report
h) Any other (e.g. combinations)

After the four subcomponents are evaluated, the CE component marks are determined as indicate in table

**23. Student Support for Learning**

1. CourseNotes
2. Reference Books in the Library
3. Magazines and Journals
4. Internet Facility
5. Computing Facility
6. Laboratory Facility
7. Workshop Facility
8. Staff Support
9. Lounges for Discussions
10. Any other support that enhances their learning

**24. Quality Control Measures**

1. Review of CourseNotes
2. Review of Question Papers and Assignment Questions
3. Student Feedback
4. Moderation of Assessed Work
5. Opportunities for students to see their assessed work
6. Review by external examiners and external examiners reports
7. Staff Student Consultative Committee meetings
8. Student exit feedback
9. Subject Assessment Board (SAB)
10. Programme Assessment Board (PAB)



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### 25. Programme Map (Course-PO-PSO Map)

| Sem. | Course Title | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Mathematical Methods of Physics | 3 | 2 | 3 | 3 | 1 | 1 | 1 | | | | 3 | 1 | |
| 1 | Classical Mechanics | 3 | 2 | 1 | 1 | 1 | 1 | | | | 1 | 3 | 1 | |
| 1 | Quantum Mechanics - 1 | 3 | 3 | 2 | | 2 | | | | 1 | 2 | 3 | 2 | 2 |
| 1 | Electronics and devices and Laboratory | 3 | 2 | 3 | 3 | 3 | 1 | 1 | | 2 | 2 | 3 | 3 | 2 |
| 1 | General Physics Laboratory-1 | 2 | 2 | 3 | 2 | 1 | 1 | 2 | 1 | 2 | | 3 | 2 | 2 |
| 1 | Matlab | | 3 | 2 | 2 | 1 | | | | | 2 | 3 | 2 | 2 |
| 2 | Electrodynamics | 3 | 2 | 3 | | 2 | | | | | 1 | 3 | 2 | 1 |
| 2 | Statistical Mechanics and Thermodynamics | 3 | 2 | 3 | | 2 | | | | 2 | 1 | 3 | 2 | 2 |
| 2 | Atomic and Molecular Physics and Laboratory | 3 | 3 | 2 | 3 | 3 | 2 | 2 | 1 | 1 | 2 | 3 | 3 | 2 |
| 2 | Solid State Physics | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 2 | 2 | 1 | 3 | 2 | 3 |
| 2 | Python Laboratory | | 3 | 2 | 2 | 1 | | | | | 2 | 3 | 2 | 2 |
| 2 | Seminar - 1 | | 2 | | | | | | | 3 | | 2 | | 3 |
| 3 | Numerical Techniques, Computational Physics and Laboratory | 3 | 2 | 3 | 3 | 1 | 1 | 1 | | | 2 | 3 | 1 | 2 |
| 3 | Quantum Mechanics - 2 | 3 | 3 | 2 | | 2 | | | | 1 | 2 | 3 | 2 | 2 |
| 3 | Nuclear and Particle Physics | 3 | 2 | 2 | 3 | 2 | 2 | | | | | 3 | 2 | 2 |
| 3 | Advanced Solid-State Physics and | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 2 |
| 3 | Nuclear Physics, Nuclear Electronics, Applications and Laboratory | 3 | 3 | 2 | 2 | 2 | 2 | 2 | | 1 | 2 | 3 | 2 | 2 |
| 3 | Research Methodology | 3 | | 3 | 3 | 3 | | | | 3 | 3 | 3 | 3 | 3 |
| 3 | Advanced Physics Laboratory | 2 | 2 | 3 | 2 | 1 | 1 | 2 | 1 | 2 | | 3 | 2 | 2 |
| 3 | Seminar - 2 | | 2 | | | | | | | 3 | | 2 | | 3 |
| 4 | Semiconductor Physics | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 2 | 2 | | 3 | 2 | 3 |
| 4 | Reactor Physics, Shielding and Safety | 3 | 3 | 2 | 2 | 2 | | | | 1 | 1 | 3 | 2 | 1 |
| 4 | Internship* | | | | | | | | | 3 | | | | 3 |
| 4 | Discipline Elective / Open Elective | | | | | | | | | | | | | |
| 4 | Dissertation | 3 | | 3 | 3 | 3 | 3 | | 3 | 3 | 2 | 3 | 3 | 3 |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | | |

### 26. Co-curricular Activities

Students are encouraged to take part in co-curricular activities like seminars, conferences, symposia, paper writing, attending industry exhibitions, project competitions and related activities for enhancing their knowledge and networking.

### 27. Cultural and Literary Activities

Annual cultural festivals are held to showcase the creative talents in students. They are involved in planning and organizing the activities.

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### 28. Sports and Athletics

Students are encouraged to take part in sports and athletic events regularly. Annual sports meet will be held to demonstrate sportsmanship and competitive spirit.

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**Course Specifications**: Mathematical Methods of Physics

| | |
|---|---|
| Course Title | Mathematical Methods of Physics |
| Course Code | PYC511A |
| Course Type | Core Theory Course |
| Department | Physics |
| Faculty | Mathematical and Physical Sciences |

## 1. Course Summary

The course aims at training students the essential mathematical tools and techniques to solve physical problems. In this course, students study the most fundamental knowledge for understanding vectors and tensors. Prior to our applying vector and tensor analysis to research area of modern continuum mechanics. Vector and tensor analysis provides a kind of bridge between elementary aspects of linear algebra, geometry and analysis. This course also deals with the underlying concepts of Fourier and Laplace transform, complex analysis and special functions.

## 2. Course Size and Credits:

| | |
|---|---|
| Number of credits | 04 |
| Credit Structure (Lecture: Tutorial: Practical) | 3:1:0 |
| Total hours of interaction | 60 |
| Number of Weeks in a Semester | 15 |
| Department responsible | Physics |
| Total Course Marks | 100 |
| Pass requirement | As per the Academic Regulations |
| Attendance requirement | As per the Academic Regulations |

## 3. Course Objectives (CO)

After the successful completion of this course, the student will be able to:

- **CO - 1** Explain the basic concepts of Vector analysis, Fourier series and Laplace transform, Complex analysis and special function.
- **CO - 2** Describe various methods of solving physics concepts using mathematical tools of Vector analysis, Fourier series and Laplace transform, Complex analysis and special function.
- **CO - 3** Solve problems on the concepts of Vector analysis, Fourier series and Laplace transform, Complex analysis and special function.
- **CO - 4** Discuss various methods of using mathematical tools of Vector analysis, Fourier series and Laplace transform, Complex analysis and special function
- **CO - 5** Apply mathematical tools for the application in quantum mechanics, classical mechanics, electronics etc.

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## 4. Course Contents

**Vector analysis and curvilinear co-ordinates:**

Transformation of vector, Curvilinear coordinates, tangent and normal vectors, contravariant and covariant components, Gradient, Curl, divergence and Laplacian operator, Cylindrical (polar)



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co-ordinates, Spherical polar co-ordinates, relation between cylindrical and spherical co-ordinates.

**Tensors:** Introduction, definitions, contraction, directs product, quotient rule, pseudo tensors, Levi- Civita symbol, irreducible tensors, non-Cartesian tensors, metric tensor, Christoffel symbols, and covariant differentiation.

**Fourier series and Laplace transform**:

Properties of Fourier series, Fourier integral, Fourier transform, inverse transform, Fourier transform of the derivative, Convolution theorem, Parseval's theorem, Laplace transform and its properties, convolution theorem, inverse Laplace transforms, solution of differential equations using Laplace transforms, Fourier and Laplace transform of Dirac Delta function

**Complex analysis:**

Functions of a complex variable, Analytic functions, Cauchy-Riemann relations – Cartesian and polar coordinates, Conjugate and harmonic nature of the real and imaginary parts of an analytic function, Cauchy's theorem, Cauchy's integral formula, Taylor and Laurent expansions, analytic continuation, classification of singularities, residue theorem, Evaluation of definite integrals.

**Special Functions:**

Linear ordinary differential equations, Poisson and Helmholtz equations in spherical polar and cylindrical polar coordinates. The gamma function and beta function; definition and simple properties. Series solutions – Frobenius' method, Series solutions of the differential equations of Bessel, Legendre, Laguerre and Hermite polynomials, Generating functions, Rodrigues formula, recurrence relations, orthogonality properties of these functions, Brief discussion of spherical Bessel functions and spherical harmonics.

## 5. Course Map (CO-PO-PSO Map)

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 1 | 2 | 1 | 3 | 1 | | | | | | 3 | 1 | |
| CO-2 | 3 | 1 | 3 | 2 | | 1 | 1 | | | | 3 | 1 | |
| CO-3 | 3 | 2 | 2 | 2 | | | | | | | 3 | | |
| CO-4 | 1 | 2 | 2 | 1 | | | | | | | 2 | | |
| CO-5 | 3 | 2 | 3 | 3 | | | | | | | 3 | 1 | |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

## 6. Course Teaching and Learning Methods

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| Face to Face Lectures | | 42 |
| Demonstrations | | 03 |
| 1. Demonstration using Videos | 00 | |
| 2. Demonstration using Physical Models / Systems | | |
| 3. Demonstration on a Computer | 03 | |
| Numeracy | | 15 |



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| | | |
|---|---|---|
| 1. Solving Numerical Problems | 15 | |
| **Practical Work** | | 00 |
| 1. Course Laboratory | | |
| 2. Computer Laboratory | | |
| 3. Engineering Workshop / Course Workshop / Kitchen | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | 00 |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry / Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| Term Tests, Written Examination | | 10 |
| Total Duration in Hours | | 70 |

### 7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment is presented in the Programme Specifications document pertaining to the M.Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document. Course reassessment policies are presented in the Academic Regulations document.

### 8 Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No. | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Classroom lectures |
| 2. | Understanding | Class room lectures, and demonstrations |
| 3. | Critical Skills | Assignment |
| 4. | Analytical Skills | Class room, assignment |
| 5. | Problem Solving Skills | Class room, assignment |
| 6. | Practical Skills | Class room, assignment |
| 7. | Group Work | Classroom |
| 8. | Self-Learning | Assignment |
| 9. | Written Communication Skills | Assignment, examination |
| 10. | Verbal Communication Skills | Presentation |
| 11. | Presentation Skills | Presentation |
| 12. | Behavioral Skills | Course |
| 13. | Information Management | Assignment, examination |
| 14. | Personal Management | Assignment, examination |

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| | | |
|---|---|---|
| 15. | Leadership Skills | Effective management of learning, time management, achieving the learning |

## 9. Course Resources

### a. Essential Reading

1. Class Notes
2. Arfken, G. and Weber, H.J. (2005) *Mathematical Methods for Physicists*, 3rd Edition, San Diego: Academic Press
3. Kreyszig, E. (2014) Advanced Engineering Mathematics, New Delhi, Wiley India Pvt. Ltd.
4. Dass, H. K. (2010) Mathematical Physics, New Delhi, S Chand.
5. Mathematical Physics with Applications, Problems and Solution, V. Balakrishnan, Ane Books, 2017.

### b. Recommended Reading

1. Joshi, A.W., (2002) Matrices and Tensors in Physics, New Delhi, Wiley Eastern.
2. P.S., (2000) Classical Mechanics, New Delhi: Tata Mc-Graw Hill Publishing Company Limited
3. Greiner. W. (2004) Classical Mechanics: System of particles and Hamiltonian Dynamics, New York: Springer-Verlag.
4. Mathematical Methods of Physics, J Mathews and RL Walker, 2nd Edition, Addison-Wesley, 1971.
5. Matrices and Tensors in Physics - AW Joshi, Wiley Eastern Ltd, 3rd edition, 1995.

### c. Magazines and Journals

1. The Physics Teacher published by the American Physical Society
2. American Journal of Physics published by the American Physical Society
3. Contemporary Physics published by the Institute of Physics
4. Resonance published by the Indian Academy of Sciences

### d. Websites

1. http://nptel.ac.in/
2. Physics Teacher Resources-aip.org

### e. Other Electronic Resources

1. YouTube physics lectures
2. YouTube physics experiments

## 10. Course Organization

| | | |
|---|---|---|
| Course Code | PYC511A | |
| Course Title | Mathematical Methods of Physics | |
| Course Leader/s Name | As per Time - table | |
| Course Leader Contact Details | Phone: | +91-804-906-5555 |
| | E-mail: | hod.pi.mp@msruas.ac.in |
| Course Specifications Approval Date | 14 July 2022 | |
| Next Course Specifications Review Date | July 2024 | |

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## Course Specifications: Classical Mechanics

| | |
|---|---|
| Course Title | Classical Mechanics |
| Course Code | PYC512A |
| Course Type | Core Theory |
| Department | Physics |
| Faculty | Faculty of Mathematical and Physical Sciences |

### 1. Course Summary

Classical mechanics exposes the student to the structure of theoretical physics. In this Course the basic principles of classical mechanics are taught in terms of the original Newtonian formulation, and the subsequent Lagrangian and Hamiltonian formulations. The complete equivalence of these three formulations is studied. The motion of bodies is described both in inertial and non-inertial frames of reference. The enunciation of the relativistic Lagrangian forms the concluding part of the programme.

### 2. Course Size and Credits:

| | |
|---|---|
| Number of credits | 04 |
| Credit Structure (Lecture: Tutorial: Practical) | 3:1:0 |
| Total hours of interaction | 60 |
| Number of Weeks in a Semester | 15 |
| Department responsible | Physics |
| Total Course Marks | 100 |
| Pass requirement | As per the Academic Regulations |
| Attendance requirement | As per the Academic Regulations |

### 3. Course Objectives (CO)

After the successful completion of this course, the student will be able to:

**CO - 1** Explain basic concepts of Lagrangian formulation, Symmetries, central forces, scattering, rigid body dynamics, small oscillations and hamitonian formalism.

**CO - 2** Describe the main results of System of particles Lagrangian formulation, Symmetries, central forces, scattering, rigid body dynamics, small oscillations and hamitonian formalism.

**CO - 3** Derive the major equation governing System of particles Lagrangian formulation, Symmetries, central forces, scattering, rigid body dynamics, small oscillations and hamitonian formalism.

**CO - 4** Solve problems on System of particles Lagrangian formulation, Symmetries, central forces, scattering, rigid body dynamics, small oscillations and hamitonian formalism.

**CO - 5** Apply the results of System of particles Lagrangian formulation, Symmetries, central forces, scattering, rigid body dynamics, small oscillations and hamiltonian formalism to relevant examples

### 4. Course Contents

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**System of particles:** Center of mass, angular momentum and kinetic energies of a system of particles, conservation of linear momentum, energy and angular momentum
**Lagrangian Formulation**: Constraints and their classification, degrees of freedom, generalized co-ordinates, virtual displacement, D'Alembert's principle, Lagrange's equations of motion of the second kind, uniqueness of the Lagrangian, Simple applications of the Lagrangian formulation: a free particle in Cartesian and plane polar coordinates, Atwood's machine; Motion of block attached to a spring; Simple pendulum; Double pendulum

**Symmetries of space time:** Cyclic coordinate, Conservation of linear momentum, angular momentum and energy.

**Central forces**: Two body central force problem, reduced mass of the system, conservation theorems, integrals of the motion, equations of motion for the orbit, classification of orbits, conditions for closed orbits, integrable power laws of the central force, Kepler's laws
**Scattering in a central force field**: general description of scattering, cross-section, impact parameter, Rutherford scattering, center of mass and laboratory coordinate systems, transformations of the scattering angle and cross-sections between them
**Motion in non-central reference frames**: Motion of a particle in a general non-inertial frame of reference, notion of pseudo forces, equations of motion in a rotating frame of reference, Coriolis force, deviation due east of a falling body, the Foucault pendulum
**Rigid body dynamics:** Degrees of freedom of a free rigid body, angular momentum and kinetic energy of a rigid body, moment of inertia tensor, principal moments of inertia, classification of rigid bodies as spherical, symmetric and asymmetric, Euler's equations of motion for a rigid body, Torque free motion of a rigid body, precession of earth's axis of rotation, Euler angles, angular velocity of a rigid body, notions of spin, precession and nutation of a rigid body.
**Small oscillations**: Types of equilibria, quadratic forms for kinetic and potential energies of a system in equilibrium, normal modes and normal frequencies- longitudinal vibrations of two coupled harmonic oscillators, Normal modes and normal frequencies of a linear, symmetric, triatomic molecule, oscillations of two linearly coupled plane pendula
**Hamiltonian formulation**: Generalized momenta, canonical coordinates, Legendre transformation and the Hamilton's equations of motion- particle in a central force field, simple harmonic oscillator, charged particle moving in an external electromagnetic field. Hamilton's equations from variational principle.
**Canonical transformation:** Generating functions, examples of canonical transformations: harmonic oscillator in one dimension. Poisson brackets, equations of motion in terms of Poisson brackets, properties of Poisson brackets, Poisson brackets of angular momentum. The Hamilton-Jacobi equation, harmonic oscillator using Hamilton-Jacobi method
**Special theory of Relativity:**
Lorentz transformation, relativistic kinematics and mass–energy equivalence, Lagrangian in Special theory relativity.

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## 5. Course Map (CO-PO-PSO Map)

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 2 | 2 | 1 | 1 | 1 | 1 | | | | 1 | 2 | 1 | |
| CO-2 | 2 | 2 | 1 | 1 | 1 | 1 | | | | 1 | 2 | 1 | |
| CO-3 | 3 | 2 | 1 | 1 | 1 | 1 | | | | 1 | 3 | 1 | |
| CO-4 | 3 | 2 | 1 | 1 | 1 | 1 | | | | 1 | 3 | 1 | |
| CO-5 | 2 | 2 | 1 | 1 | 1 | 1 | | | | 1 | 2 | 1 | |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

## 6. Course Teaching and Learning Methods

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| **Face to Face Lectures** | | 42 |
| **Demonstrations** | | 03 |
| 1.Demonstration using Videos | 01 | |
| 2.Demonstrationusing Physical Models / Systems | | |
| 3.Demonstration on a Computer | 02 | |
| **Numeracy** | | 15 |
| 1. Solving Numerical Problems | 15 | |
| **Practical Work** | | 00 |
| 1. Course Laboratory | | |
| 2. Computer Laboratory | | |
| 3. Engineering Workshop / Course Workshop / Kitchen | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | 00 |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry / Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| Term Tests, Written Examination | | 10 |
| Total Duration in Hours | | 70 |

## 9 Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No. | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Classroom lectures |

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| | | |
|---|---|---|
| 2. | Understanding | Class room lectures, and demonstrations |
| 3. | Critical Skills | Assignment |
| 4. | Analytical Skills | Class room, assignment |
| 5. | Problem Solving Skills | Class room, assignment |
| 6. | Practical Skills | Class room, assignment |
| 7. | Group Work | Classroom |
| 8. | Self-Learning | Assignment |
| 9. | Written Communication Skills | Assignment, examination |
| 10. | Verbal Communication Skills | Presentation |
| 11. | Presentation Skills | Presentation |
| 12. | Behavioral Skills | Course |
| 13. | Information Management | Assignment, examination |
| 14. | Personal Management | Assignment, examination |
| 15. | Leadership Skills | Effective management of learning, time management, achieving the learning outcomes |

**11. Course resources**

**f. Essential Reading**

1. Class Notes
2. Goldstein, H., Poole, C. & Saiko, J. (2002) Classical Mechanics. 3rd Edition. New Delhi: Pearson Education Asia.
3. John R Taylor, (2005) Classical Mechanics, New York: University Science books,

**g. Recommended Reading**

1. Hasbun, J. E. (2009) Classical Mechanics with Matlab Applications. Toronto: Jones & Bartlett Learning.
2. Takawale, R. G. & Puranik, P. S. (2001) Introduction to Classical Mechanics. New Delhi: Tata McGraw Hill.
3. Barger, V. & Olsson, M. (1995) Classical Mechanics: A Modern Perspective, 2nd Edition, New York: Mc Graw Hill.
4. Rana, N.C. & Joag, P.S., (2000) Classical Mechanics, New Delhi: Tata Mc-Graw Hill Publishing Company Limited.
5. Landau, L.D. & Lifshitz, E.M., (1976) Mechanics, UK: Pergamon.
6. Greiner. W. (2004) Classical Mechanics: System of particles and Hamiltonian Dynamics, New York: Springer-Verlag.
7. Srinivasa Rao K.N. (2002) Classical Mechanics, University press.

**h. Magazines and Journals**

1. The Physics Teacher published by the American Physical Society
2. American Journal of Physics published by the American Physical Society
3. Contemporary Physics published by the Institute of Physics
4. Resonance published by the Indian Academy of Sciences

**i. Websites**

3. http://nptel.ac.in/
4. Physics Teacher Resources-aip.org

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j. **Other Electronic Resources**

1. Electronic resources on the subject area are available on MSRUAS library

12. **Course Organization**

| | | | |
|---|---|---|---|
| **Course Code** | PYC512A | | |
| **Course Title** | Classical Mechanics | | |
| **Course Leader/s Name** | | As per Time - table | |
| **Course Leader Contact Details** | | **Phone:** | +91-804-906-5555 |
| | | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | | 14 July 2022 | |
| **Next Course Specifications Review Date** | | July 2024 | |

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**Course Specification:** Quantum Mechanics - 1

| | |
|---|---|
| Course Title | Quantum Mechanics - 1 |
| Course Code | PYC513A |

| Course Type | Core Theory Course |
|---|---|
| Department | Physics |
| Faculty | Faculty of Mathematical and Physical Sciences |

## 1. Course Summary

Quantum mechanics (along with General Relativity) is one of the two foundational theories on which modern physics rests. This course provides an overview of the historical evidence that led to the development of quantum theory of matter and light. This is followed by key elements of quantum mechanics, including the Schrodinger wave equation, statistical interpretation of wave functions, the role of operators and their connection with observables and uncertainty. These concepts are initially introduced and reinforced through relatively simple problems with analytic solutions, but computational solutions are also examined where appropriate. The course also covers general formalism of quantum mechanics and angular momentum algebra.

## 2. Course Size and Credits:

| | |
|---|---|
| Number of credits | 4 |
| Credit structure (Lecture: Tutorial: Practical) | 3:1:0 |
| Total hours of interaction | 60 |
| Number of weeks in a semester | 15 |
| Department responsible | Physics |
| Total course marks | 100 |
| Pass requirement | As per academic regulations |
| Attendance requirement | As per academic regulations |

## 3. Course Objectives

After the successful completion of this course, the student will be able to:

**CO - 1** Explain the basic concepts of one-dimensional problems, general formalism, angular momentum and introductory results.

**CO - 2** Describe the major results of one-dimensional problems, general formalism, angular momentum and introductory results

**CO - 3** Derive the major equation governing introductory concepts, one dimensional problems, general formalism and angular momentum.

**CO - 4** Solve numerical problems on introductory concepts, one dimensional problems, general formalism and angular momentum.

**CO - 5** Apply the central results of introductory concepts, one dimensional problems, general formalism and angular momentum to relevant examples.

## 4. Course Contents

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**Introductory concepts:** Wave-particle duality, interpretation of the wave function, wave function for particles having a definite momentum, Schrodinger equation, Gaussian wave Packets and their time evolution, Fourier transform and momentum space wave function, Heisenberg uncertainty principle for position and momentum, conservation of probability, operators and expectation values, Ehrenfest theorem, time-independent Schrodinger equation, stationary states and their properties, energy quantization, properties of energy Eigen functions, general solution of the time dependent Schrodinger equation for a time independent potential.

**One-dimensional problems:** Free-particle, box normalization, Eigenvalues and Eigen functions of particle in a) infinitely deep potential b) finite square well potential, and c) simple harmonic oscillator potential, potential barrier - transmission and reflection coefficients. Extension to three dimensional problems: Separation of the Schrodinger equation in Cartesian coordinates, particle in a three dimensional box. (15 hours)

**General formalism of quantum theory:** operator methods: Hilbert space, linear operators, observables, Dirac notation, Eigen functions of Hermitian operators, degeneracy, commutation of operators and compatibility, generalized uncertainty principle for two non-commuting observables, Unitary transformations, time-dependence of observables: Schrodinger and Heisenberg pictures, Simple harmonic oscillator by operator method.

**Angular momentum:** Orbital angular momentum commutation relations, Eigenvalues and Eigenfunctions, Central potential, separation of variables in the Schrodinger equation, the radial equation, the Hydrogen atom. General operator algebra of angular momentum operators Jx, Jy, Jz. Ladder operators, eigenvalues and eigenkets of J2 and Jz, matrix representations of angular momentum operators, Pauli matrices, addition of angular momentum, Clebsch-Gordan coefficients for the casej1 = j2=1/2. (15 hours)

## 5. Course Map (CO-PO-PSO Map)

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 3 | 3 | | | | | | | 1 | 2 | 3 | | 2 |
| CO-2 | 3 | 3 | | | | | | | | 2 | 3 | | 2 |
| CO-3 | 3 | 3 | 2 | | 2 | | | | 1 | 2 | 3 | 2 | 2 |
| CO-4 | 3 | 3 | 2 | | 2 | | | | | 2 | 3 | 2 | 2 |
| CO-5 | 3 | 3 | 2 | | 2 | | | | | 2 | 3 | 2 | 2 |

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## 6. Course Teaching and Learning Methods

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| **Face to Face Lectures** | | 40 |
| **Demonstrations** | | |
| 1. Demonstration using Videos | | |
| 2. Demonstration using Physical Models / | | |
| 3. Demonstration on a Computer | 5 | |
| **Numeracy** | | 15 |
| 1. Solving Numerical Problems | 10 | |
| **Practical Work** | | 00 |
| 1. Course Laboratory | | |
| 2. Computer Laboratory | | |
| 3. Engineering Workshop / Course Workshop / Kitchen | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | 00 |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry / Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| Term Tests, Written Examination | | 10 |
| Total Duration in Hours | | 70 |

### 7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment is presented in the Programme Specifications document pertaining to the M.Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document.

### 10 Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No. | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Classroom lectures |
| 2. | Understanding | Class room lectures, and demonstrations |
| 3. | Critical Skills | Assignment |
| 4. | Analytical Skills | Class room, assignment |
| 5. | Problem Solving Skills | Class room, assignment |
| 6. | Practical Skills | Class room, assignment |
| 7. | Group Work | Classroom |
| 8. | Self-Learning | Assignment |

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| | | |
|---|---|---|
| 9. | Written Communication Skills | Assignment, examination |
| 10. | Verbal Communication Skills | Presentation |
| 11. | Presentation Skills | Presentation |
| 12. | Behavioral Skills | Course |
| 13. | Information Management | Assignment, examination |
| 14. | Personal Management | Assignment, examination |
| 15. | Leadership Skills | Effective management of learning, time management, achieving the learning |

**13. Course resources**

**a. Essential Reading**

k. Class Notes
l. Griffiths D.J. (2004) Introduction to Quantum Mechanics, Third Edition, Pearson Education
m. Liboff.(2007) Introductory Quantum Mechanics, 4th Edition, Pearson Education Ltd.
n. Arul Das. (2000) Quantum Mechanics, Prentice Hall of India.
o. Ghatak A. K. & Lokanathan S., (1997) Quantum Mechanics, McMillan India Ltd.

**b. Recommended Reading**

1. Schiff L. I. (1968) Quantum Mechanics, McGraw Hill Publishers.
2. Sakurai (2002) Modern Quantum Mechanics, Pearon Education Asia.
3. Crasemann B. & Powell J. H., (1988) Quantum Mechanics, Narosa Publishing House.
4. Feynman R. P, Leighton R. B. & Matthew Sands., (1966) The Feynman Lectures on Physics, Vol. III, Addison-Wesley Publishing Company, Inc.

**c. Magazines and Journals**

1. The Physics Teacher published by the American Physical Society
2. American Journal of Physics published by the American Physical Society
3. Contemporary Physics published by the Institute of Physics
4. Resonance published by the Indian Academy of Sciences

**d. Websites**

5. http://nptel.ac.in/

**e. Other Electronic Resources**

a. Youtube quantum mechanics lectures

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14. **Course Organization**

| | | | |
|---|---|---|---|
| **Course Code** | PYC513A | | |
| **Course Title** | Quantum mechanics - 1 | | |
| **Course Leader/s Name** | | As per Time - table | |
| **Course Leader Contact Details** | | **Phone:** | +91-804-906-5555 |
| | | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | | 14 July 2022 | |
| **Next Course Specifications Review Date** | | July 2024 | |

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**Course Specifications:** Electronics and devices and Laboratory

| | |
|---|---|
| Course Title | Electronics and devices and Laboratory |
| Course Code | PYC514A |
| Course Type | Core Theory Course |
| Department | Physics |
| Faculty | Mathematical and Physical Sciences |

## 1. Course Summary

The course aims at training students in the basic components of electronics: diodes, transistors, and op-amps. It covers basic operations and some common applications. This course also deals with the underlying concepts of Op-Amps and Digital electronics.

## 2. Course Size and Credits:

| | |
|---|---|
| Number of credits | 05 |
| Credit Structure (Lecture: Tutorial: Practical) | 3:1:1 |
| Total hours of Interaction | 60 + 30 |
| Number of Weeks in a Semester | 15 |
| Department responsible | Physics |
| Total Course Marks | 100 |
| Pass requirement | As per the Academic Regulations |
| Attendance requirement | As per the Academic Regulations |

## 8. Course Objectives (CO)

After the successful completion of this course, the student will be able to:

- **CO - 1** Explain the basics of electronic devices, opto-electronic Devices, Operational Amplifier and Digital Electronics
- **CO - 2** Describe and derive standard relationships in pn junctions, optoelectronic devices
- **CO - 3** Analyse and design BJT and FET/MOSFET circuits
- **CO - 4** Construct an OPAMP circuit for different applications
- **CO - 5** Conduct appropriate experiments as per the standard procedures and tabulate the measured values and analyze the results

## 9. Course Contents

**Basics of Electronic devices:**

p-n junction , abrupt junction – band structure – thermal equilibrium – depletion region – depletion capacitance – Qualitative description of current flow at a Junction; Diode equation (No derivation), BJT – band structure - transistor action – static characteristics.

JFET structure, working, characteristics. MOSFET – Basic operation and structure, Depletion and Enhancement mode MOSFET – Principle and working, calculation of threshold voltage – V-I characteristics.

**Opto-electronic Devices:**

Principle of operation of photo electronic devices: photoconductor – efficiency, current gain, response time. Effect of light on I-V characteristics of a junction photo device, Light dependent



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resistor (LDR), Principle and working of a photodiode and Solar cell, Light emitting diode, principle, working and factors affecting the efficiency of LED

**Operational Amplifier and its applications**

Block diagram of an operational amplifier – Characteristics of an ideal operational amplifier– Operational amplifier as an open loop amplifier – inverting and non-inverting amplifiers - Voltage follower – Differential amplifier: voltage gain. Summing amplifier – inverting and non-inverting configurations, Subtractor, difference summing amplifier, Differentiator, Integrator. Applications of op-amp: Linear applications – Phase and frequency response of low pass, high pass and band pass.

Non – linear applications: comparators, positive and negative clippers and clampers

**Digital Electronics:**

Review of gates (AND, OR, NAND, NOR, NOT, EX-OR), - Boolean laws and theorems – Flip flops: Latch using NAND and NOR gates- RS flip flop, clocked RS flip flop, JK flip flop, JK master slave flip flop – racing – Shift Registers basics – Counters: Ripple counters truth table – timing diagram, Synchronous counters-truth table-timing diagram, A/D and D/A convertor, Decade counter.

## 10. Course Map (CO-PO-PSO Map)

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 3 | 2 | 3 | 2 | 1 | | | | | | 3 | 2 | |
| CO-2 | 2 | 2 | 2 | 1 | 1 | | | | | | 2 | 1 | |
| CO-3 | 3 | 1 | 3 | 2 | 3 | 1 | 1 | | 2 | | 3 | 3 | 2 |
| CO-4 | 2 | 1 | 2 | 2 | 1 | 1 | | | | | 2 | 2 | |
| CO-5 | 3 | 2 | 2 | 3 | 3 | | | | 2 | | 2 | 3 | 2 |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

## 11. Course Teaching and Learning Methods

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| **Face to Face Lectures** | | 42 |
| **Demonstrations** | | 03 |
| 1. Demonstration using Videos | 02 | |
| 2. Demonstration using Physical Models / Systems | | |
| 3. Demonstration on a Computer | 01 | |
| **Numeracy** | | 15 |
| 1. Solving Numerical Problems | 15 | |
| **Practical Work** | | 30 |
| 1. Course Laboratory | | |
| 2. Computer Laboratory | | |
| 3. Engineering Workshop / Course Workshop | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | 00 |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry / Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |

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| | | |
|---|---|---|
| 6. Discussing Possible Innovations | | |
| Term Tests, Written Examination | | 10 |
| | Total Duration in Hours | 100 |

**12. Course Assessment and Reassessment**

The details of the components and subcomponents of course assessment is presented in the Programme Specifications document pertaining to the M.Sc., Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document. Course reassessment policies are presented in the Academic Regulations document.

**11 Achieving COs**

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No. | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Classroom lectures |
| 2. | Understanding | Class room lectures, |
| 3. | Critical Skills | Assignment |
| 4. | Analytical Skills | Class room, assignment |
| 5. | Problem Solving Skills | Class room, assignment |
| 6. | Practical Skills | Class room, assignment |
| 7. | Group Work | Classroom |
| 8. | Self-Learning | Assignment |
| 9. | Written Communication Skills | Assignment, examination |
| 10. | Verbal Communication Skills | -- |
| 11. | Presentation Skills | -- |
| 12. | Behavioral Skills | Course work |
| 13. | Information Management | Assignment, examination |
| 14. | Personal Management | Assignment, examination |
| 15. | Leadership Skills | -- |

**15. Course Resources**

**p. Essential Reading**


1. Class Notes
2. SM Sze, (2006) Semiconductor Devices Physics and Technology, 3rd Edition, John Wiley and Sons Inc. Asia.
3. Malvino, A.P. and Bates, J., (2016) Electronic Principles, Eighth Edition, Tata McGraw Hill, Delhi.
4. Gayakwad, R.A., (2004) Op-Amps and Linear Integrated Circuits, 4thEdition, Eastern Economy Edition.


**q. Recommended Reading**


1. Ben G Streetman, Sanjay Bannerjee, (2014) Solid State Electronic Devices, 7th edition, Pearson, Asia.
2. Leach, D. P. and Malvino, A.P. Digital principles and applications, 5thEdition, Tata McGraw Hill, 2002.
3. MichealShur, (1996) Introduction to electronic devices, PHI.


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**r. Magazines and Journals**

1. The Physics Teacher published by the American Physical Society
2. American Journal of Physics published by the American Physical Society
3. Contemporary Physics published by the Institute of Physics
4. Resonance published by the Indian Academy of Sciences

**s. Websites**

https://electronicsforu.com/

**e. Other Electronic Resources**

1. Youtube electronics lectures
2. Youtube instrumentation experiments

16. **Course Organization**

| | | |
|---|---|---|
| **Course Code** | PYC514A | |
| **Course Title** | Electronics and devices and Laboratory | |
| **Course Leader/s Name** | As per Time - table | |
| **Course Leader Contact Details** | **Phone:** | 080 4906 5555 |
| | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | 14 July 2022 | |
| **Next Course Specifications Review Date** | July 2024 | |

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**Course Specifications:** Electrodynamics

| | |
|---|---|
| Course Title | Electrodynamics |
| Course Code | PYC521A |
| Course Type | Core Theory Course |
| Department | Physics |
| Faculty | Mathematical and Physical Sciences |

## I. Course Summary

The course introduces the students to the principles of electrostatics, magnetostatics, electrodynamics, electromagnetic waves and plasma dynamics. The calculation of electric and magnetic fields from charge and current distributions will be illustrated. The propagation of electromagnetic waves in homogeneous media and waveguides will be discussed.

## 2. Course Size and Credits:

| | |
|---|---|
| **Number of credits** | 04 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 3:1:0 |
| **Total hours of interaction** | 60 |
| **Number of Weeks in a Semester** | 15 |
| **Department responsible** | Physics |
| **Total Course Marks** | 100 |
| **Pass requirement** | As per the Academic Regulations |
| **Attendance requirement** | As per the Academic Regulations |

## 13. Course Objectives (CO)

After the successful completion of this course, the student will be able to:

**CO - 1** Understand the basics and explain the concepts of electrostatics, magnetostatics, electromagnetic waves, electromagnetic radiations

**CO - 2** Derive expressions for electric fields and potentials, magnetic fields, electric field and potential, magnetic field, induced electric field, maxwells equations.

**CO - 3** Discuss, derive expressions for the electromagnetic waves in different media, E M waves propagation from one medium to another medium, dynamics of charged particles.

**CO - 4** Discuss, derive expressions for scalar and vector potential, transformations, retarded potentials, Electric dipole radiation, magnetic dipole radiation, Power radiated by a point charge

**CO - 5** Solve the problems using the concepts of electrostatics, magnetostatics, electrodynamics, electromagnetic wave, electromagnetic radiation

## 14. Course Contents

**Electrostatics:**

Review of mathematical foundations. Coulomb's law, Electric field, Gauss's law, Divergence and curl of electric field, applications of Gauss's law. Electric potential, Poisson's equation, Laplace's equation, potential of a localized charge distribution, Electrostatic boundary conditions. Work and energy in Electrostatics, Laplace's equations in one, two and three

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dimensions, Boundary conditions and Uniqueness Theorems. The method of images, Induced surface charge, force and energy. Separation of variables, Multipole expansion, Electric field of a dipole, Polarization in dielectrics, the field of a polarised object, Susceptibility, permittivity and dielectric constant.

**Magnetostatics:**
The Lorentz force law, Magnetic field, Biot-Savart law, magnetic field of a steady current. Divergence and curl of B, Ampere's law and applications. Magnetic vector potential, Multipole expansion of the vector potential, Magnetic fields in matter - diamagnets, paramagnets and ferromagnets, Ampere's law in magnetized materials, Magnetic susceptibility and permeability.

**Electrodynamics**
Faraday's law, induced electric field, energy in magnetic fields, Maxwell's equations, Maxwell's equations in matter, Boundary conditions. Poynting's theorem

**Electromagnetic waves**:

Electromagnetic waves in vacuum, energy and momentum in electromagnetic waves. Electromagnetic waves in matter, E M waves propagation in linear media, Reflection and transmission at normal incidence, Reflection and transmission at oblique incidence. Electromagnetic waves in conductors, reflection at a conducting surface, and frequency dependence of permittivity. Wave guides, TE waves in a rectangular wave guide. Co-axial transmission line, Dynamics of charged particles in static and uniform electromagnetic fields.

**Electromagnetic radiation**:
Scalar and vector potentials, Gauge transformations, Coulomb and Lorentz gauge, retarded potentials, Lienard-Wiechert potentials, the fields of a moving point charge. Electric dipole radiation, magnetic dipole radiation, Power radiated by a point charge. Review of Lorentz transformations, Transformation of electric and magnetic Fields.

## 15. Course Map (CO-PO-PSO Map)

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 2 | 2 | 3 | | 2 | | | | | | 3 | 2 | |
| CO-2 | 2 | 2 | 2 | | | | | | | | 2 | | |
| CO-3 | 1 | 1 | 2 | | | | | | | | 2 | | |
| CO-4 | 3 | 2 | 2 | | 1 | | | | | 1 | 3 | 1 | 1 |
| CO-5 | 2 | | 1 | | | | | | | | 2 | | |
| | 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | |

## 16. Course Teaching and Learning Methods

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| Face to Face Lectures | | 42 |
| Demonstrations | | 03 |
| 1. Demonstration using Videos | 01 | |
| 2. Demonstration using Physical Models / Systems | | |
| 3. Demonstration on a Computer | 02 | |



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| | | |
|---|---|---|
| **Numeracy** | | 15 |
| 1. Solving Numerical Problems | 15 | |
| **Practical Work** | | |
| 1. Course Laboratory | | |
| 2. Computer Laboratory | | |
| 3. Engineering Workshop/Course Workshop/Kitchen | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry/Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| Term Tests and Written Examination | | 10 |
| Total Duration in Hours | | 70 |

## 17. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment is presented in the Programme Specifications document pertaining to the M.Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document. Course reassessment policies are presented in the Academic Regulations document.

## 12 Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No. | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Classroom lectures |
| 2. | Understanding | Class room lectures, and demonstrations |
| 3. | Critical Skills | Assignment |
| 4. | Analytical Skills | Class room, assignment |
| 5. | Problem Solving Skills | Class room, assignment |
| 6. | Practical Skills | Class room, assignment |
| 7. | Group Work | Classroom |
| 8. | Self-Learning | Assignment |
| 9. | Written Communication Skills | Assignment, examination |
| 10. | Verbal Communication Skills | Presentation |
| 11. | Presentation Skills | Presentation |
| 12. | Behavioral Skills | Course |
| 13. | Information Management | Assignment, examination |
| 14. | Personal Management | Assignment, examination |



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| | | |
|---|---|---|
| 15. | Leadership Skills | Effective management of learning, time management, achieving the learning |

**17. Course Resources**

a. **Essential Reading**

1. Class Notes
2. Jackson, J.D. (1998) Classical Electrodynamics, Third Edn, John Wiley.
3. Griffiths D.J. (2002) Introduction to Electrodynamics, Prentice-hall of India.

b. **Recommended Reading**

1. Lorrain P. & Corson D., Electromagnetic fields and waves, CBS.
2. Panofsky & Phillips., (2008) Classical electricity and magnetism, 2nd edn, Dover Publications.
3. Sadiku. (2009) Electromagnetics, 4th edition, Oxford: Oxford Press.

c. **Magazines and Journals**

1. The Physics Teacher published by the American Physical Society
2. American Journal of Physics published by the American Physical Society
3. Contemporary Physics published by the Institute of Physics
4. Resonance published by the Indian Academy of Sciences

d. **Websites**

1. Physics Teacher Resources-aip.org

e. **Other Electronic Resources**

1. http://nptel.ac.in/
2. Youtube physics lectures

18. **Course Organization**

| | | | |
|---|---|---|---|
| **Course Code** | PYC521A | | |
| **Course Title** | Electrodynamics | | |
| **Course Leader/s Name** | | As per time table | |
| **Course Leader Contact Details** | | **Phone:** | 080 4906 5555 |
| | | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | | 14 July 2022 | |
| **Next Course Specifications Review Date:** | | 2024 | |

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## Course Specifications: General Physics Laboratory

| | |
|---|---|
| Course Title | General Physics Laboratory |
| Course Code | PYL515A |
| Course Type | Laboratory Course |
| Department | Physics |
| Faculty | Mathematical and Physical Sciences |

### 1. Course Summary

This course intends to expose the students to the challenges and rewards related to experimental physics. Students gain hands-on experience by conducting experiments in a controlled laboratory environment. Students are trained to conduct experiments related to mechanics. They are trained to analyze the measurements, results and infer appropriate conclusions based on fundamental concepts of Physics.

### 2. Course Size and Credits:

| | |
|---|---|
| **Number of credits** | 02 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 0:0:2 |
| **Total hours of class room interaction** | 60 |
| **Number of semester weeks** | 15 |
| **Department responsible** | Physics |
| **Total Course marks** | 50 |
| **Pass requirement** | As per the Academic Regulations |
| **Attendance requirement** | As per the Academic Regulations |

### 3. Course Outcomes (COs)

After the successful completion of this course, the student will be able to:

- **CO - 1** Setup the experimental apparatus required to achieve the stated aim
- **CO - 2** Conduct experiments as per the standard procedures and tabulate the measured values
- **CO - 3** Calculate the required parameters and plot the results
- **CO - 4** Interpret and draw conclusions
- **CO - 5** Write laboratory report as per the prescribed format

### 4. Course Contents

1 Error propagation and analysis and least squares fit method.
2 Stefan's constant of radiation
3 Thermal diffusivity of brass
4 Statistics of counting of background radiation using GM counter
5 Verification of Fresnel's laws
6 Maxwell's bridge and DeSauty's bridge
7 Dielectric constant of non-polar liquid and Comparison of capacitance
8 Thermal and Electric conductivity to find Lorentz number

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9 Millikan oil drop experiment
10 Determination of elastic constants of glass (and Perspex) by Cornu's interference method
11 Determination of wavelength of Sodium vapour lamp using Michelson interferometer and Fabry-Perot interferometer
12 Normal modes in 3-dimensional box
13 Verification of Brewster's law and Malus law

5. **Course Map (CO-PO-PSO Map)**

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 2 | 2 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | | 3 | 2 | 2 |
| CO-2 | 2 | 1 | 3 | 2 | 1 | | 1 | | | | 3 | 2 | 1 |
| CO-3 | | | 3 | 1 | | | 1 | | | | 3 | 1 | 1 |
| CO-4 | 2 | 1 | 2 | 1 | 1 | | 1 | | | | 2 | 1 | 1 |
| CO-5 | 1 | | | | | | | | 2 | | 1 | | 2 |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

6. **Course Teaching and Learning Methods**

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| **Face to Face Lectures** | | |
| **Demonstrations** | | 00 |
| 1. Demonstration using Videos | | |
| 2. Demonstration using Physical Models / Systems | | |
| 3. Demonstration on a Computer | | |
| **Numeracy** | | 00 |
| 1. Solving Numerical Problems | | |
| **Practical Work** | | 60 |
| 1. Course Laboratory | 60 | |
| 2. Computer Laboratory | | |
| 3. Engineering Workshop / Course Workshop / Kitchen | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | 00 |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry / Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| Term Tests, Laboratory Examination / Written Examination, Presentations | | 06 |
| Total Duration in Hours | | 66 |

7. **Achieving Learning Outcomes**

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The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Laboratory instruction |
| 2. | Understanding | Laboratory instructions and experiments |
| 3. | Critical Skills | Laboratory work |
| 4. | Analytical Skills | Laboratory work |
| 5. | Problem Solving Skills | Laboratory work |
| 6. | Practical Skills | Laboratory work |
| 7. | Group Work | Laboratory work |
| 8. | Self-Learning | Laboratory work |
| 9. | Written Communication Skills | Laboratory work, examination |
| 10. | Verbal Communication Skills | Laboratory examination |
| 11. | Presentation Skills | -- |
| 12. | Behavioral Skills | Course work |
| 13. | Information Management | Laboratory work |
| 14. | Personal Management | Course work |
| 15. | Leadership Skills | -- |

8. **Course Resources**
   a. **Essential Reading**
      4. Laboratory manual
      5. Kumar, P.R.S., (2011) *Practical Physics*, Prentice Hall India Learning Private Limited.
      6. Subrahmanyam, N. and Brijlal, (2012) *A Text book of Optics*, New Delhi: S. Chand & Company
   b. **Recommended Reading**
      1. Frank S Crawford Jr, (2008) *Waves*, New Delhi: Tata Mcgraw-Hill Publishing Company Limited
   c. **Magazines and Journals**
   d. **Websites**
      1. Physics Teacher Resources-aip.org
   e. **Other Electronic Resources**
      1. Youtube physics experiments

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9. **Course Organization**

| | | | |
|---|---|---|---|
| Course Code | PYL515A | | |
| Course Title | General Physics Laboratory | | |
| Course Leader/s Name | As per Time - table | | |
| Course Leader Contact Details | Phone: | +91-804-906-5555 | |
| | E-mail: | hod.pi.mp@msruas.ac.in | |
| Course Specifications Approval Date | 14 July 2022 | | |
| Next Course Specifications Review Date | July 2024 | | |

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**Course Specifications:** Matlab and Python Laboratory

| | |
|---|---|
| Course Title | Matlab Laboratory |
| Course Code | PYL516A |
| Course Type | Laboratory Course |
| Department | Physics |
| Faculty | Mathematical and Physical Sciences |

**10. Course Summary**

This course intends to expose the students to the challenges and rewards related to experimental physics. Students gain hands-on experience by conducting experiments in a controlled laboratory environment. Students are trained to conduct experiments related to mechanics. They are trained to analyze the measurements, results and infer appropriate conclusions based on fundamental concepts of Physics.

**11. Course Size and Credits:**

| | |
|---|---|
| **Number of credits** | 01 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 0:0:1 |
| **Total hours of class room interaction** | 30 |
| **Number of semester weeks** | 15 |
| **Department responsible** | Physics |
| **Total Course marks** | 50 |
| **Pass requirement** | As per the Academic Regulations |
| **Attendance requirement** | As per the Academic Regulations |

**12. Course Outcomes (COs)**

After the successful completion of this course, the student will be able to:

**CO - 1** Understand basic operations of MatLab

**CO - 2** Write and execute the programmes to learn and understand functions and dictionaries

**CO - 3** Understand basic operations of Matlab, write and execute Matlab code for required parameters and plot the results

**CO - 4** Interpret and draw conclusions

**CO - 5** Write laboratory report as per the prescribed format

**13. Course Contents**

1. Introduction to MATLAB.
2. Basic arithmetic operations in MATLAB.
3. Matrix operations in MATLAB.
4. Command line functions.
5. Scripts and functions.
6. Relational and logical operators.
7. Control structures in MATLAB.
8. Looping structures in MATLAB.
9. Symbolic computations: Differentiation and integration.

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10. 2D and 3D plots.

## 14. Course Map (CO-PO-PSO Map)

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | | 1 | | | | | | | | | 1 | | |
| CO-2 | | 3 | | 2 | 1 | | | | | | 3 | 2 | |
| CO-3 | | 2 | | | 1 | | | | | | 2 | 1 | |
| CO-4 | | 2 | 2 | 2 | 1 | | | | | | 2 | 2 | |
| CO-5 | | | | | | | | | | 2 | | | 2 |

3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution

## 15. Course Teaching and Learning Methods

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| **Face to Face Lectures** | | 00 |
| **Demonstrations** | | 00 |
| 1. Demonstration using Videos | | |
| 2. Demonstration using Physical Models / Systems | | |
| 3. Demonstration on a Computer | | |
| **Numeracy** | | 00 |
| 1. Solving Numerical Problems | | |
| **Practical Work** | | 30 |
| 1. Course Laboratory | 30 | |
| 2. Computer Laboratory | | |
| 3. Engineering Workshop / Course Workshop / Kitchen | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | 00 |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry / Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| Term Tests, Laboratory Examination / Written Examination, Presentations | | 06 |
| Total Duration in Hours | | 36 |

## 16. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M.Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document. Course reassessment policies are presented in the Academic Regulations document.

## 17. Achieving Learning Outcomes

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The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Laboratory instruction |
| 2. | Understanding | Laboratory instructions and experiments |
| 3. | Critical Skills | Laboratory work |
| 4. | Analytical Skills | Laboratory work |
| 5. | Problem Solving Skills | Laboratory work |
| 6. | Practical Skills | Laboratory work |
| 7. | Group Work | Laboratory work |
| 8. | Self-Learning | Laboratory work |
| 9. | Written Communication Skills | Laboratory work, examination |
| 10. | Verbal Communication Skills | Laboratory examination |
| 11. | Presentation Skills | -- |
| 12. | Behavioral Skills | Course work |
| 13. | Information Management | Laboratory work |
| 14. | Personal Management | Course work |
| 15. | Leadership Skills | -- |

**18. Course Resources**

f. **Essential Reading**

7. Laboratory manual
8. B. Nagesh Rao, (2017) learning *Python*, CyberPlus Infotech Pvt. Ltd., Bangalore
9. Rudra Pratap (2018), *Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers*, Oxford India

g. **Recommended Reading**

h. **Magazines and Journals**

i. **Other Electronic Resources**

2. Youtube videos on MatLab and Python courses

**19. Course Organization**

| Course Code | PYL516A | |
|---|---|---|
| Course Title | MatLab | |
| Course Leader/s Name | | As per Time - table |
| Course Leader Contact Details | | **Phone:** +91-804-906-5555<br>**E-mail:** hod.pi.mp@msruas.ac.in |
| Course Specifications Approval Date | | 14 July 2022 |
| Next Course Specifications Review Date | | July 2024 |

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**Course Specifications:** Electrodynamics

| | |
|---|---|
| Course Title | Electrodynamics |
| Course Code | PYC521A |
| Course Type | Core Theory Course |
| Department | Physics |
| Faculty | Mathematical and Physical Sciences |

## I. Course Summary

The course introduces the students to the principles of electrostatics, magnetostatics, electrodynamics, electromagnetic waves and plasma dynamics. The calculation of electric and magnetic fields from charge and current distributions will be illustrated. The propagation of electromagnetic waves in homogeneous media and waveguides will be discussed.

## 2. Course Size and Credits:

| | |
|---|---|
| **Number of credits** | 04 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 3:1:0 |
| **Total hours of interaction** | 60 |
| **Number of Weeks in a Semester** | 15 |
| **Department responsible** | Physics |
| **Total Course Marks** | 100 |
| **Pass requirement** | As per the Academic Regulations |
| **Attendance requirement** | As per the Academic Regulations |

## 18. Course Objectives (CO)

After the successful completion of this course, the student will be able to:

**CO - 1** Understand the basics and explain the concepts of electrostatics, magnetostatics, electromagnetic waves, electromagnetic radiations

**CO - 2** Derive expressions for electric fields and potentials, magnetic fields, electric field and potential, magnetic field, induced electric field, maxwells equations.

**CO - 3** Discuss, derive expressions for the electromagnetic waves in different media, E M waves propagation from one medium to another medium, dynamics of charged particles.

**CO - 4** Discuss, derive expressions for scalar and vector potential, transformations, retarded potentials, Electric dipole radiation, magnetic dipole radiation, Power radiated by a point charge

**CO - 5** Solve the problems using the concepts of electrostatics, magnetostatics, electrodynamics, electromagnetic wave, electromagnetic radiation

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## 19. Course Contents

**Electrostatics:**

Review of mathematical foundations. Coulomb's law, Electric field, Gauss's law, Divergence and curl of electric field, applications of Gauss's law. Electric potential, Poisson's equation, Laplace's equation, potential of a localized charge distribution, Electrostatic boundary conditions. Work and energy in Electrostatics, Laplace's equations in one, two and three

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dimensions, Boundary conditions and Uniqueness Theorems. The method of images, Induced surface charge, force and energy. Separation of variables, Multipole expansion, Electric field of a dipole, Polarization in dielectrics, the field of a polarised object, Susceptibility, permittivity and dielectric constant.

**Magnetostatics:**
The Lorentz force law, Magnetic field, Biot-Savart law, magnetic field of a steady current. Divergence and curl of B, Ampere's law and applications. Magnetic vector potential, Multipole expansion of the vector potential, Magnetic fields in matter - diamagnets, paramagnets and ferromagnets, Ampere's law in magnetized materials, Magnetic susceptibility and permeability.

**Electrodynamics**
Faraday's law, induced electric field, energy in magnetic fields, Maxwell's equations, Maxwell's equations in matter, Boundary conditions. Poynting's theorem

**Electromagnetic waves**:

Electromagnetic waves in vacuum, energy and momentum in electromagnetic waves. Electromagnetic waves in matter, E M waves propagation in linear media, Reflection and transmission at normal incidence, Reflection and transmission at oblique incidence. Electromagnetic waves in conductors, reflection at a conducting surface, and frequency dependence of permittivity. Wave guides, TE waves in a rectangular wave guide. Co-axial transmission line, Dynamics of charged particles in static and uniform electromagnetic fields.

**Electromagnetic radiation**:
Scalar and vector potentials, Gauge transformations, Coulomb and Lorentz gauge, retarded potentials, Lienard-Wiechert potentials, the fields of a moving point charge. Electric dipole radiation, magnetic dipole radiation, Power radiated by a point charge. Review of Lorentz transformations, Transformation of electric and magnetic Fields.

## 20. Course Map (CO-PO-PSO Map)

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 2 | 2 | 3 | | 2 | | | | | | 3 | 2 | |
| CO-2 | 2 | 2 | 2 | | | | | | | | 2 | | |
| CO-3 | 1 | 1 | 2 | | | | | | | | 2 | | |
| CO-4 | 3 | 2 | 2 | | 1 | | | | | 1 | 3 | 1 | 1 |
| CO-5 | 2 | | 1 | | | | | | | | 2 | | |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

## 21. Course Teaching and Learning Methods

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| Face to Face Lectures | | 42 |
| Demonstrations | | 03 |
| 3. Demonstration using Videos | 01 | |
| 4. Demonstration using Physical Models / Systems | | |
| 3. Demonstration on a Computer | 02 | |

| | | |
|---|---|---|
| **Numeracy** | | 15 |
| 1. Solving Numerical Problems | 15 | |
| **Practical Work** | | |
| 1. Course Laboratory | | |
| 2. Computer Laboratory | | |
| 3. Engineering Workshop/Course Workshop/Kitchen | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry/Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| Term Tests and Written Examination | | 10 |
| Total Duration in Hours | | 70 |

**22. Course Assessment and Reassessment**

The details of the components and subcomponents of course assessment is presented in the Programme Specifications document pertaining to the M.Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document. Course reassessment policies are presented in the Academic Regulations document.

**13 Achieving COs**

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No. | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Classroom lectures |
| 2. | Understanding | Class room lectures, and demonstrations |
| 3. | Critical Skills | Assignment |
| 4. | Analytical Skills | Class room, assignment |
| 5. | Problem Solving Skills | Class room, assignment |
| 6. | Practical Skills | Class room, assignment |
| 7. | Group Work | Classroom |
| 8. | Self-Learning | Assignment |
| 9. | Written Communication Skills | Assignment, examination |
| 10. | Verbal Communication Skills | Presentation |
| 11. | Presentation Skills | Presentation |
| 12. | Behavioral Skills | Course |
| 13. | Information Management | Assignment, examination |
| 14. | Personal Management | Assignment, examination |



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| | | |
|---|---|---|
| 15. | Leadership Skills | Effective management of learning, time management, achieving the learning |

**19. Course Resources**

**f. Essential Reading**

10. Class Notes
11. Jackson, J.D. (1998) Classical Electrodynamics, Third Edn, John Wiley.
12. Griffiths D.J. (2002) Introduction to Electrodynamics, Prentice-hall of India.

**g. Recommended Reading**

1. Lorrain P. & Corson D., Electromagnetic fields and waves, CBS.
2. Panofsky & Phillips., (2008) Classical electricity and magnetism, 2nd edn, Dover Publications.
3. Sadiku. (2009) Electromagnetics, 4th edition, Oxford: Oxford Press.

**h. Magazines and Journals**

1. The Physics Teacher published by the American Physical Society
2. American Journal of Physics published by the American Physical Society
3. Contemporary Physics published by the Institute of Physics
4. Resonance published by the Indian Academy of Sciences

**i. Websites**

2. Physics Teacher Resources-aip.org

**j. Other Electronic Resources**

3. http://nptel.ac.in/
4. Youtube physics lectures

20. **Course Organization**

| | | | |
|---|---|---|---|
| **Course Code** | PYC521A | | |
| **Course Title** | Electrodynamics | | |
| **Course Leader/s Name** | | As per time table | |
| **Course Leader Contact Details** | | **Phone:** | 080 4906 5555 |
| | | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | | 14 July 2022 | |
| **Next Course Specifications Review Date:** | | 2024 | |

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Medha. G. Rao

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**Course Specifications:** Statistical Mechanics and Thermodynamics

| | |
|---|---|
| Course Title | Statistical Mechanics and Thermodynamics |
| Course Code | PYC522A |
| Course Type | Core Theory Course |
| Department | Physics |
| Faculty | Faculty of Mathematical and Physical Sciences |

## 1. Course Summary

This course introduces students to the use of statistical methods of analysis of physical systems. After introducing the concepts of microcanonical, canonical and grand canonical ensembles, the methods of statistical mechanics are used to develop the statistics for Bose-Einstein and Fermi-Dirac statistics. The statistical methods of analysis are applied to analyse the phase transition in liquid He, Bose-Einstein condensation and black body radiation. The behavior of physical systems under non equilibrium conditions is discussed in the framework of fluctuation- dissipation theorem.

## 2. Course Size and Credits:

| | |
|---|---|
| Number of credits | 4 |
| Credit Structure (Lecture: Tutorial: Practical) | 3:1:0 |
| Total hours of interaction | 60 |
| Number of Weeks in a Semester | 15 |
| Department responsible | Physics |
| Total Course Marks | 100 |
| Pass requirement | As per the Academic Regulations |
| Attendance requirement | As per the Academic Regulations |

## 23. Course Objectives (CO)

After the successful completion of this course, the student will be able to:

**CO - 1** Discuss basic concepts of different statistical ensembles, their distribution functions, ranges of applicability and corresponding thermodynamic potentials.

**CO - 2** Discuss statistical physics methods, such as Boltzmann distribution, Gibbs distribution, Fermi-Dirac and Bose-Einstein distributions to solve problems in physical system

**CO – 3** Discuss statistical methods to analyze phase transitions, Black Body Radiation and Bose-Einstein condensation.

**CO - 4** Make connections between applications of general statistical theory in various branches of physics

**CO - 5** Apply statistical physics methods, such as Boltzmann distribution, Gibbs distribution, Fermi-Dirac and Bose-Einstein distributions to solve problems in physical system

## 24. Course Contents

Basic Concepts-Introduction, Laws of thermodynamics and their consequences. Thermodynamic potentials, Maxwell relations, chemical potential, phase space, Ergodic Hypothesis, ensemble, ensemble average, Liouville theorem, condition for statistical



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equilibrium, micro canonical ensemble, ideal gas, Quantum picture: Micro canonical ensemble, quantization of phase space, basic postulates, classical limit, symmetry of wave functions, effect of symmetry on counting

Ensembles and Partition Functions-Canonical ensemble, entropy of a system in contact with a heat reservoir, ideal gas in canonical ensemble, Maxwell velocity distribution, equipartition of energy, Grand canonical ensemble, ideal gas in grand canonical ensemble, comparison of various ensembles. Canonical partition function, molecular partition function, translational partition function, rotational partition function, electronic and nuclear partition functions, application of rotational partition function, application of vibrational partition function to solids.

Ideal Bose-Einstein and Fermi-Dirac gases Bose-Einstein distribution, Bose-Einstein condensation, thermodynamic properties of an ideal Bose-Einstein gas, liquid helium, two fluid model of liquid helium-II, superfluid phases of 3He, Fermi-Dirac(FD) statistics, properties of ideal Fermi gas, degeneracy, FD distribution

First- and second-order phase transitions. Diamagnetism, para-magnetism, and ferromagnetism. Ising model. Bose-Einstein condensation. Diffusion equation. Random walk and Brownian motion. Introduction to non-equilibrium processes.

## 25. Course Map (CO-PO-PSO Map)

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 2 | 2 | 3 | | 2 | | | | | | 3 | 2 | |
| CO-2 | 2 | 2 | 2 | | | | | | | | 2 | | |
| CO-3 | 1 | 1 | 2 | | 1 | | | | | | 2 | 1 | |
| CO-4 | 3 | 2 | 2 | | | | | | 2 | 1 | 3 | | 2 |
| CO-5 | 2 | | 1 | | | | | | | | 2 | | |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

26. **Course Teaching and Learning Methods**

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| **Face to Face Lectures** | | 42 |
| **Demonstrations** | | 03 |
| 5. Demonstration using Videos | 1 | |
| 6. Demonstration using Physical Models/Systems | | |
| 3. Demonstration on a Computer | 2 | |
| **Numeracy** | | 15 |
| 1. Solving Numerical Problems | 15 | |
| **Practical Work** | | |
| 1. Course Laboratory | | |
| 2. Computer Laboratory | | |
| 3. Engineering Workshop/Course | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry/Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| Term Tests and Written Examination | | 10 |
| Total Duration in Hours | | 70 |

**27. Course Assessment and Reassessment**

The details of the components and subcomponents of course assessment is presented in the Programme Specifications document pertaining to the M.Sc. in Physics Programme. The procedure to determine the final course marks is also presented in the Programme Specifications document.

Course reassessment policies are presented in the Academic Regulations document.

**14 Achieving COs**

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No. | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Classroom lectures |
| 2. | Understanding | Class room lectures, and demonstrations |
| 3. | Critical Skills | Assignment |
| 4. | Analytical Skills | Class room, assignment |
| 5. | Problem Solving Skills | Class room, assignment |

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| | | |
|---|---|---|
| 6. | Practical Skills | Class room, assignment |
| 7. | Group Work | Classroom |
| 8. | Self-Learning | Assignment |
| 9. | Written Communication Skills | Assignment, examination |
| 10. | Verbal Communication Skills | Presentation |
| 11. | Presentation Skills | Presentation |
| 12. | Behavioral Skills | Course |
| 13. | Information Management | Assignment, examination |
| 14. | Personal Management | Assignment, examination |
| 15. | Leadership Skills | Effective management of learning, time management, achieving the learning |

**21. Course Resources**

**a. Essential Reading**

a. Class Notes
b. Agarwal B.K.& Melvin Eisner., (1998) Statistical Mechanics,2ndEdn, New Age International.
c. Pathria R.K. (2006) Statistical Mechanics,2nd edition, Butterworth Heinemann.
d. Reif , F.(1985) Statistical and Thermal Physics, McGraw Hill International.
e. Huang K. (1991) Statistical Mechanics, Wiley Eastern Limited.

**b. Recommended Reading**

1. Laud B.B. (2003) Fundamentals of Statistical Mechanics, New Age International Publication.
2. Keith Stowe. (1984) An introduction to Thermodynamics and Statistical Mechanics, John Wiley& sons.
3. Zemansky ,M. & Dittman, R., (1981) Heat and Thermodynamics ,McGraw-Hill.

**c. Magazines and Journals**

**a. Websites**

1. Physics Teacher Resources-aip.org

**b. Other Electronic Resources**

1. YouTube physics lectures
2. YouTube physics experiments

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22. **Course Organization**

| | | | |
|---|---|---|---|
| **Course Code** | PYC522A | | |
| **Course Title** | Statistical Mechanics and Thermodynamics | | |
| **Course Leader/s Name** | As per time table | | |
| **Course Leader Contact Details** | **Phone:** | 080 4906 5555 | |
| | **E-mail:** | hod.pi.mp@msruas.ac.in | |
| **Course Specifications Approval Date** | 14 July 2022 | | |
| **Next Course Specifications Review** | July 2024 | | |

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## **Course Specifications:** Atomic and Molecular Physics

| | |
|---|---|
| Course Title | Atomic and Molecular Physics |
| Course Code | PYC523A |
| Course Type | Core Theory Course |
| Department | Physics |
| Faculty | Mathematical and Physical Sciences |

### 1. Course Summary

The aim of this course is to enable the students to understand and apply the important concepts of atomic and molecular spectroscopy. This course covers fundamentals of atomic and molecular energy level systems. The course provides an insight into emission and absorption spectroscopy of atomic, diatomic and polyatomic molecules. Effect of electric and magnetic fields on atomic and molecular system are dealt in detail.

### 2. Course Size and Credits:

| | |
|---|---|
| Number of credits | 05 |
| Credit Structure (Lecture: Tutorial: Practical) | 3:1:1 |
| Total hours of interaction | 60 + 30 = 90 |
| Number of Weeks in a Semester | 15 |
| Department responsible | Physics |
| Total Course Marks | 100 |
| Pass requirement | As per the Academic Regulations |
| Attendance requirement | As per the Academic Regulations |

### 28. Course Objectives (CO)

After the successful completion of this course, the student will be able to:

**CO - 1** Explain the basic concepts of spectroscopy, atomic and molecular physics, and lasers

**CO - 2** Describe various models and derive important mathematical expressions in lasers, atomic and molecular systems

**CO - 3** Discuss and analyze different types of interactions of matter with external fields, manifestation of their energy levels, applications of lasers, molecular spectroscopy and resonance techniques

**CO - 4** Solve problems on lasers, spin resonance, and atomic and molecular physics

**CO - 5** Conduct appropriate experiments as per the standard procedures and tabulate the measured values and analyze the results

### 29. Course Contents

**Fundamentals of spectroscopy and Lasers:** Characterization of electromagnetic radiation: Electromagnetic spectrum, the quantization of EMR, types of spectra. Width and shapes of spectral lines: lifetime of excited states, pressure broadening, Doppler broadening.

Lasers: Absorption and emission of EMR by matter, Einstein's coefficients, characteristics of laser, spatial and temporal coherence, condition for producing laser, population inversion, role of resonant cavity, Ruby Laser, He-Ne Laser, brief treatment of applications of lasers

**Atomic Physics:**

Brief review of early atomic models of Bohr and Sommerfeld: One electron atom, atomic orbitals. Spectrum of Hydrogen atom: energy levels and selection rules, Rydberg atoms, relativistic



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correction to the kinetic energy, spin-orbit interaction and fine structure in alkali spectra. Lamb shift. hyperfine structure, energy shift, hyperfine transition in Hydrogen, Isotope shifts.

**Interaction with external fields:**

Zeeman effect and anomalous Zeeman effect, magnetic interaction energy, selection rules, splitting of levels in Hydrogen atom. Linear stark effect, order correction to energy and Eigen states. Paschen-Back effect. Two electron atom- ortho & para states, role of Pauli exclusion principle, level schemes of two electron atoms. Many electron atoms: LS and JJ coupling scheme, Lande interval rule. Franck-Condon principle,

Review of spin resonance techniques: fundamentals of electron spin resonance and nuclear magnetic resonance, chemical shift, relaxation mechanisms (spin-spin and spin-lattice), NMR spectrometer and applications of NMR in solids and liquids.

**Molecular Physics:**

Born-Oppenheimer approximation (qualitative). Classification of molecules. Rotational spectra of diatomic molecules as a rigid rotator, centrifugal distortion and non-rigid rotator Intensity of rotational lines, rotational spectra of symmetric rotors, Raman scattering and polarizability, rotational Raman spectrum of diatomic and linear polyatomic molecules. Applications of Raman spectroscopy.

**Vibrational Spectroscopy:**

Vibrational energy of diatomic molecule, diatomic molecules as simple harmonic oscillator, anharmonicity, effect of anharmonicity on vibrational terms, energy levels and spectrum, Morse potential energy curve, vibrational Raman effect, Rovibronic spectrum of a diatomic molecule with example. Diatomic molecules in excited vibrational states. Mutual exclusion principle, Correlation between Raman and IR spectroscopy, Applications of IR spectroscopy in material characterization and structural elucidation

**Experiments:**

Experiments based on the concepts on atomic and molecular physics, and lasers. Experimental data interpretation and analysis of advanced spectroscopic techniques (Raman and IR), Data analysis of spin resonance techniques with appropriate programs/softwares.

1. To determine the Wavelength of H-alpha Emission Line of Hydrogen Atom.
2. To determine the value of e/m by (a) Magnetic Focusing or (b) Bar Magnet.
3. Study of characteristic properties of a given diode laser
4. To determine the wavelengths of Hydrogen spectrum and hence to determine the value of Rydberg's Constant.
5. Analyse the temperature dependent $^1$H NMR $T_1$ relaxation data to identify the phase transition temperatures and estimate the activation energies ($E_a$)
6. To determine the Absorption Lines in the Rotational Spectrum of Iodine vapour.
7. To determine line spectra of inert gases and metal vapors using a prism spectrometer.
8. To determine the wavelengths of Cu/Fe/CN arc spectrum
9. Analysis of CN band spectrum.
10. Analysis of NO band structure.
11. To study the FTIR/Raman spectrum of given molecule.

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## 30. Course Map (CO-PO-PSO Map)

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 3 | 2 | | | | | 2 | | | 2 | 3 | | 2 |
| CO-2 | | 3 | 1 | | | | | 1 | 1 | | 3 | 1 | 1 |

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| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-3 | 2 | | | 1 | 3 | | | | | 1 | 2 | 3 | 1 |
| CO-4 | | 2 | | 3 | | | 2 | 1 | | | 2 | 3 | 2 |
| CO-5 | | | 2 | | 3 | 2 | | | 1 | | 2 | 3 | 2 |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

31. **Course Teaching and Learning Methods**

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| **Face to Face Lectures** | | **42** |
| **Demonstrations** | | **03** |
| 1. Demonstration using videos | 03 | |
| 2. Demonstration using Physical Models / Systems | | |
| 3. Demonstration on a Computer | | |
| **Numeracy** | | 15 |
| 1. Solving Numerical Problems | 15 | |
| **Practical Work** | | 30 |
| 1. Course Laboratory | 30 | |
| 2. Computer Laboratory | | |
| 3. Engineering Workshop / Course Workshop / Kitchen | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | 00 |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry / Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| Term Tests, Written Examination | | 10 |
| Total duration in hours | | 100 |

**32. Course Assessment and Reassessment**

The details of the components and subcomponents of course assessment is presented in the Programme Specifications document pertaining to the M.Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document.

**The evaluation questions are set to measure the attainment of the COs. In either components (CE or SEE), COs are assessed.**

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

**Course reassessment policies are presented in the Academic Regulations document.**

**15 Achieving COs**

The following skills are directly or indirectly imparted to the students in the following

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teaching and learning methods:

| S. No. | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Classroom lectures |
| 2. | Understanding | Class room lectures, and demonstrations |
| 3. | Critical Skills | Assignment |
| 4. | Analytical Skills | Class room, assignment |
| 5. | Problem Solving Skills | Class room, assignment |
| 6. | Practical Skills | Class room, assignment |
| 7. | Group Work | Classroom |
| 8. | Self-Learning | Assignment |
| 9. | Written Communication Skills | Assignment, examination |
| 10. | Verbal Communication Skills | Presentation |
| 11. | Presentation Skills | Presentation |
| 12. | Behavioral Skills | Course |
| 13. | Information Management | Assignment, examination |
| 14. | Personal Management | Assignment, examination |
| 15. | Leadership Skills | Effective management of learning, time management, achieving the learning outcomes |

**23. Course Resources**

**t. Essential Reading**

13. Class notes
14. White, H.E., (1934) *Introduction to Atomic Spectra*, New Delhi, McGraw Hill.
15. Rita Kakkar, (2017) *Atomic and Molecular Spectroscopy: Basic Concepts and Applications*, India, Cambridge.
16. Banwell. C. N., (2017) *Fundamentals of Molecular Spectroscopy*, New Delhi, McGraw Hill Education.
17. Thyagrajan & Ghatak, (2010) *Lasers - Fundamentals and Applications*, Springer.
18. Malcolm H. Levitt, (2008) *Spin Dynamics: Basics of Nuclear Magnetic Resonance*, 2nd edition, Wiley.

**u. Recommended Reading**

1. SuneSvanberg., (2004) *Atomic and Molecular Spectroscopy: Basic Aspects and Practical Applications*, Springer.
2. Jain, V. K., (2009) *Introduction to Atomic and Molecular Spectroscopy*, New Delhi, Narosa Book Distributors.
3. Mallikarjunaiah K. J. and Ramakrishna Damle, (2011) *Solid-State NMR and its implications in molecular dynamics study*, LAP Lambert Academic Publishing, Germany
4. Simon Hooker and Colin Webb, (2010), *Laser Physics*, Oxford Master Series in Physics

**v. Magazines and Journals**

5. Solid-State Nuclear Magnetic Resonance, Applied Magnetic Resonance, Ceramics International, Journal of Magnetism and Magnetic Materials

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6. Biophysical Journal published by Cell
7. Magnetic Resonance in Chemistry published by Wiley

**w. Websites**

1. www.ocw.mit.edu/courses/physics

**x. Other Electronic Resources**

1. http://nptel.ac.in/
2. https://www.coursera.org/

24. **Course Organization**

| | | | |
|---|---|---|---|
| **Course Code** | PYC523A | | |
| **Course Title** | Atomic and Molecular Physics | | |
| **Course Leader/s Name** | | As per Time - table | |
| **Course Leader Contact Details** | | **Phone:** | +91-804-906-5555 |
| | | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | | 14 July 2022 | |
| **Next Course Specifications Review Date** | | July 2024 | |

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**Course Specifications:** Solid State Physics

| | |
|---|---|
| Course Title | Solid State Physics |
| Course Code | PYC524A |
| Course Type | Core Theory Course |
| Department | Physics |
| Faculty | Faculty of Mathematical and Physical Sciences |

## 1. Course Summary

This course gives an introduction to solid state physics with emphasis on crystal structures and crystal symmetry of materials. The primary aim is to explain the various properties of crystals on the basis of structure, bonding and composition. Also, it enables the students to understand the thermal and electrical properties of crystals. The application of quantum mechanics to the study of solid state is highlighted.

## 2. Course Size and Credits:

| | |
|---|---|
| **Number of credits** | 04 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 3:1:0 |
| **Total hours of interaction** | 60 |
| **Number of Weeks in a Semester** | 15 |
| **Department responsible** | Physics |
| **Total Course Marks** | 100 |
| **Pass requirement** | As per the Academic Regulations |
| **Attendance requirement** | As per the Academic Regulations |

## 33. Course Objectives (CO)

After the successful completion of this course, the student will be able to:

**CO - 1** Explain the basics of crystal structure and crystal systems in terms of lattice and basis of constituent atoms and different thermal and electrical properties of crystals

**CO - 2** Analyze the relation between crystal symmetry and crystal properties and discuss how X-ray diffraction in crystals can be utilized to determine the crystal structure and other properties

**CO - 3** Solve numerical problems on crystal structure, x-ray diffraction, thermal and electrical properties of crystals

**CO - 4** Describe various types of crystal growth techniques and discuss atomic vibrations, heat capacity, thermal expansion and thermoelectric effects in crystalline solids

**CO - 5** Apply quantum theory to electronic transport properties of metals, semiconductors and superconductors

## 34. Course Contents

### Crystal Structure

Crystalline state - periodic arrangement of atoms - lattice translation vectors. The basis and crystal structure, primitive and non-primitive lattice cell - Bravais lattice and crystal systems, directions and crystal planes - miller indices. Elements of symmetry operations - point groups and space groups- Quasi crystals.

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**X-ray Diffraction**

X-ray diffraction, Reciprocal lattice, Bragg's law in vectorial form, Ewald sphere, Laue equations, X-ray scattering by a single atom, X-ray scattering from a crystal, Scattering factor, X-ray diffractometer, X ray diffraction from cubic crystals, Systematic absences, calculation of structure factors for sc, bcc and fcc lattices.

**Crystal Growth Techniques**

Methods of crystal growth-Growth from solution, hydrothermal growth, Growth in gel media, Sol-gel method, Growth from melt, Czochralski method, Bridgman method, epitaxial growth, molecular beam epitaxy, chemical vapour deposition, metal oxide chemical vapour deposition, ball milling, lithography and ion beam lithography.

**Thermal properties of crystals**

Specific heat - Atomic vibrations-Debye and Debye's Model- Electronic contribution to specific heat - Thermal expansion of crystals - Thermal conduction in solids - Thermoelectric effects Thermal Materials: Materials for thermal insulation-Cryogenic materials - Thermoelectric materials.

**Electrical properties of Crystals**

Classical and Quantum theory of metallic conductivity - Hall effect and magneto resistance, photoelectric emission, thermionic emission - Field emission - Superconductors, Properties - Type I and II superconductors - BCS theory, Josephson effect, Tunneling in superconductors, Applications.

35. **Course Map (CO-PO-PSO Map)**

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 3 | 3 | 1 | | 1 | 2 | 1 | | 1 | 1 | 3 | 1 | 2 |
| CO-2 | 3 | 2 | | 2 | | | 2 | | | 1 | 3 | 2 | 1 |
| CO-3 | 2 | 2 | 1 | | | 2 | | | 1 | | 2 | | 2 |
| CO-4 | 3 | 2 | | | 2 | 2 | | 2 | | | 3 | 2 | 2 |
| CO-5 | 3 | 2 | 1 | 2 | | | 3 | | 2 | 1 | 3 | 2 | 3 |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

36. **Course Teaching and Learning Methods**

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| **Face to Face Lectures** | | 42 |
| **Demonstrations** | | 03 |
| 1. Demonstration using Videos | | |
| 2. Demonstration using Physical Models / Systems | 1 | |
| 3. Demonstration on a Computer | 2 | |
| **Numeracy** | | 15 |
| 1. Solving Numerical Problems | 15 | |
| **Practical Work** | | 00 |
| 1. Course Laboratory | | |
| 2. Computer Laboratory | | |



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| | | |
|---|---|---|
| 3. Engineering Workshop/Course Workshop/ Kitchen | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | 00 |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry / Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| Term Tests, Written Examination | | 10 |
| | Total Duration in Hours | 70 |

**37. Course Assessment and Reassessment**

The details of the components and subcomponents of course assessment is presented in the Programme Specifications document pertaining to the M.Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

**16 Achieving COs**

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No. | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Classroom lectures |
| 2. | Understanding | Class room lectures, and demonstrations |
| 3. | Critical Skills | Assignment |
| 4. | Analytical Skills | Class room, assignment |
| 5. | Problem Solving Skills | Class room, assignment |
| 6. | Practical Skills | Class room, assignment |
| 7. | Group Work | Classroom |
| 8. | Self-Learning | Assignment |
| 9. | Written Communication Skills | Assignment, examination |
| 10. | Verbal Communication Skills | Presentation |
| 11. | Presentation Skills | Presentation |
| 12. | Behavioral Skills | Course |
| 13. | Information Management | Assignment, examination |
| 14. | Personal Management | Assignment, examination |
| 15. | Leadership Skills | Effective management of learning, time management, achieving the learning outcomes |

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**9 Course resources**

**y. Essential Reading**

1. Class Notes
2. Kittel, C. (2004) Introduction to Solid State Physics, 7th Edn, John Wiley.
3. Aschcroft N.W & Mermin N.D., (1976) Solid State Physics, Saunders College Publishing, Harcourt Brace College publishers, New York.
4. Wahab, M. A., (1999) Solid State Physics, Narosa Publishing House, New Delhi.
5. Pillai, S.O., (2002) Solid State Physics, New Age International Publication.
6. Dekker, A.J., (1981) Solid State Physics, Macmillan India Ltd, Bangalore

**b. Recommended Reading**

1. Callister W.D. (1997) Materials Science and Engineering-An Introduction, New York: John Wiley.
2. Smith W.F. (1990) Principles of Materials Science and Engineering, McGraw Hill.
3. Phillips F.C. (1963) An introduction to Crystallography, ELBS, London.
4. Srinivasan, M. R. (2009) Applied Solid State Physics, New Delhi: New Age International Publishers.

**c. Magazines and Journals**

1. The Physics Teacher published by the American Physical Society
2. American Journal of Physics published by the American Physical Society
3. Contemporary Physics published by the Institute of Physics
4. Resonance published by the Indian Academy of Sciences

**d. Websites**

Physics Teacher Resources-aip.org

**e. Other Electronic Resources**

1. Electronic resources on the subject area are available on MSRUAS library
2. Youtube physics lectures
3. Youtube physics experiments

25. **Course Organization**

| | | | |
|---|---|---|---|
| **Course Code** | PC524A | | |
| **Course Title** | Solid State Physics | | |
| **Course Leader/s Name** | | As per Time - table | |
| **Course Leader Contact Details** | | **Phone:** | +91-804-906-5555 |
| | | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | | 14 July 2022 | |
| **Next Course Specifications Review Date** | | July 2024 | |

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**Course Specifications:** Matlab and Python Laboratory

| | |
|---|---|
| Course Title | Python Laboratory |
| Course Code | PYL525A |
| Course Type | Laboratory Course |
| Department | Physics |
| Faculty | Mathematical and Physical Sciences |

**20. Course Summary**

This course intends to expose the students to the challenges and rewards related to experimental physics. Students gain hands-on experience by conducting experiments in a controlled laboratory environment. Students are trained to conduct experiments related to mechanics. They are trained to analyze the measurements, results and infer appropriate conclusions based on fundamental concepts of Physics.

**21. Course Size and Credits:**

| | |
|---|---|
| **Number of credits** | 02 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 1:0:1 |
| **Total hours of class room interaction** | 45 |
| **Number of semester weeks** | 15 |
| **Department responsible** | Physics |
| **Total Course marks** | 50 |
| **Pass requirement** | As per the Academic Regulations |
| **Attendance requirement** | As per the Academic Regulations |

**22. Course Outcomes (COs)**

After the successful completion of this course, the student will be able to:

**CO - 1** Understand the IDE, syntax, algorithms, functions, control structures of Python

**CO - 2** Understand the functions, control structures of Python

**CO - 3** Write and execute the programmes to learn and understand control structures, functions, sets, strings, file handling, dictionaries

**CO - 4** Write and execute the programmes to learn strings, file handling, dictionaries

**CO - 5** Write laboratory report as per the prescribed format

**23. Course Contents**

**Python:**

Programming in python: python interpreter, editors, IDE's, Scripts, data types, Identifiers, key words, variables, input, output, control structures – decisions, loops; lists, sets, functions, strings, dictionaries, file handling (qualitative)

1. Introduction: Introduction to IDE and programming environment
2. Simple instructions: Development of programs using variables, different data types, operators and expressions
3. Input/Output: Development of programs to read user input from screen and display output to the screen

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4. Logic operations and decision making: Development of programs using logic operations and conditional statements
5. Loops: Development of programs using various loop statements and blocks of code
6. Character and string operations: Development of programs using string manipulation algorithms such as reversal, comparison, update of string
7. User defined functions: Development of programs using numerical computation

**24. Course Map (CO-PO-PSO Map)**

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | | 1 | | | | | | | | | 1 | | |
| CO-2 | | 3 | | 2 | 1 | | | | | | 3 | 2 | |
| CO-3 | | 2 | | | 1 | | | | | | 2 | 1 | |
| CO-4 | | 2 | 2 | 2 | 1 | | | | | | 2 | 2 | |
| CO-5 | | | | | | | | | | 2 | | | 2 |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

**25. Course Teaching and Learning Methods**

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| **Face to Face Lectures** | | 15 |
| **Demonstrations** | | 00 |
| 1. Demonstration using Videos | | |
| 2. Demonstration using Physical Models / Systems | | |
| 3. Demonstration on a Computer | | |
| **Numeracy** | | 00 |
| 1. Solving Numerical Problems | | |
| **Practical Work** | | 45 |
| 1. Course Laboratory | 30 | |
| 2. Computer Laboratory | | |
| 3. Engineering Workshop / Course Workshop / Kitchen | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | 00 |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry / Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| Term Tests, Laboratory Examination / Written Examination, Presentations | | 06 |
| Total Duration in Hours | | 51 |

**26. Course Assessment and Reassessment**

The details of the components and subcomponents of course assessment are presented in the



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Programme Specifications document pertaining to the M.Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document. Course reassessment policies are presented in the Academic Regulations document.

**27. Achieving Learning Outcomes**

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Laboratory instruction |
| 2. | Understanding | Laboratory instructions and experiments |
| 3. | Critical Skills | Laboratory work |
| 4. | Analytical Skills | Laboratory work |
| 5. | Problem Solving Skills | Laboratory work |
| 6. | Practical Skills | Laboratory work |
| 7. | Group Work | Laboratory work |
| 8. | Self-Learning | Laboratory work |
| 9. | Written Communication Skills | Laboratory work, examination |
| 10. | Verbal Communication Skills | Laboratory examination |
| 11. | Presentation Skills | -- |
| 12. | Behavioral Skills | Course work |
| 13. | Information Management | Laboratory work |
| 14. | Personal Management | Course work |
| 15. | Leadership Skills | -- |

**28. Course Resources**

j. **Essential Reading**
   19. Laboratory manual
   20. B. Nagesh Rao, (2017) learning *Python*, CyberPlus Infotech Pvt. Ltd., Bangalore
   21. Rudra Pratap (2018), *Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers*, Oxford India

k. **Recommended Reading**

l. **Magazines and Journals**

m. **Other Electronic Resources**
   3. Youtube videos on MatLab and Python courses

**29. Course Organization**

| Course Code | PYL525A | |
|---|---|---|
| Course Title | Python Laboratory | |
| Course Leader/s Name | As per Time - table | |
| Course Leader Contact Details | Phone: | +91-804-906-5555 |
| | E-mail: | hod.pi.mp@msruas.ac.in |
| Course Specifications Approval Date | 14 July 2022 | |
| Next Course Specifications Review Date | July 2024 | |

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## Course Specifications: Seminar 1

| | |
|---|---|
| Course Title | Seminar 1 |
| Course Code | PYS526A |
| Course Type | Core Laboratory Course |
| Department | Physics |
| Faculty | Mathematical and Physical Sciences |

### 1. Course Summary

The aim of this course is to train students to conduct independent study a topic of relevance and deliver a seminar.

The student is expected choose a topic of relevance and conduct independent study. The student is also expected to submit a report and present the same.

### 2. Course Size and Credits:

| | |
|---|---|
| **Number of Credits** | 01 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 0:0:1 |
| **Total Hours of Interaction** | 30 |
| **Number of Weeks in a Semester** | 15 |
| **Department Responsible** | Physics |
| **Total Course Marks** | 50 |
| **Pass Criterion** | As per the Academic Regulations |
| **Attendance Requirement** | As per the Academic Regulations |

### 3. Course Outcomes (COs)

After the successful completion of this course, the student will be able to:

**CO-1.** Conduct a thorough literature review and submit a review article / scientific report
**CO-2.** Make a presentation to a panel of examiners

### 4. Course Contents

Choose the relevant research topic
Study literature and give seminar
Prepare a review article/ scientific report and give a presentation on the same topic

### 5. Course Map (CO-PO-PSO Map)

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | | 2 | | | | | | | 3 | | 2 | | 3 |
| CO-2 | | 2 | | | | | | | 3 | | 2 | | 3 |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

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## 6. Course Teaching and Learning Methods

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| **Face to Face Lectures** | | |
| **Demonstrations** | | 00 |
| 1. Demonstration using Videos | 00 | |
| 2. Demonstration using Physical Models / Systems | 00 | |
| 3. Demonstration on a Computer | 00 | |
| **Numeracy** | | 00 |
| 1. Solving Numerical Problems | 00 | |
| **Practical Work** | | 00 |
| 1. Course Laboratory | 00 | |
| 2. Computer Laboratory | 00 | |
| 3. Engineering Workshop / Course/Workshop / Kitchen | 00 | |
| 4. Clinical Laboratory | 00 | |
| 5. Hospital | 00 | |
| 6. Model Studio | 00 | |
| **Others** | | 30 |
| 1. Case Study Presentation | 30 | |
| 2. Guest Lecture | 00 | |
| 3. Industry / Field Visit | 00 | |
| 4. Brain Storming Sessions | 00 | |
| 5. Group Discussions | 00 | |
| 6. Discussing Possible Innovations | 00 | |
| Term Tests, Laboratory Examination/Written Examination, Presentations | | 01 |
| **Total Duration in Hours** | | **31** |

## 7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M. Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document. Course reassessment policies are presented in the Academic Regulations document.

## 8. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Literature reading |
| 2. | Understanding | Literature reading |
| 3. | Critical Skills | Literature reading |
| 4. | Analytical Skills | Literature reading |
| 5. | Problem Solving Skills | Drawing conclusions from the literature |
| 6. | Practical Skills | Literature reading, preparation of report |
| 7. | Group Work | |
| 8. | Self-Learning | Literature reading, preparation of report |

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| | | |
|---|---|---|
| 9. | Written Communication Skills | Preparation of report |
| 10. | Verbal Communication Skills | Presentation of report |
| 11. | Presentation Skills | Presentation of report |
| 12. | Behavioral Skills | Course work |
| 13. | Information Management | Presentation of report |
| 14. | Personal Management | Course work |
| 15. | Leadership Skills | --- |

## 9. Course Resources

a. **Essential Reading**

1. Books / Research Articles

## 10. Course Organization

| | | |
|---|---|---|
| **Course Code** | PYS526A | |
| **Course Title** | Seminar 1 | |
| **Course Leader's Name** | As per Timetable | |
| **Course Leader's Contact Details** | **Phone:** | +91-804-906-5555 |
| | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | 14 July 2022 | |
| **Next Course Specifications Review Date** | July 2024 | |

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**Course Specifications:** Numerical Techniques, Computational Physics and Laboratory

| | |
|---|---|
| Course Title | Numerical Techniques, Computational Physics and Laboratory |
| Course Code | PYC611A |
| Course Type | Core Theory Course |
| Department | Physics |
| Faculty | Faculty of Mathematical and Physical Sciences |

## I. Course Summary

This course introduces students to learn mathematical methods to analyze physical systems. Further course emphasizes the various numerical analysis covers a wide range of methods and applications in physics. In this course, we introduce the most important concepts underlying DFT, its foundation, and basic ideas. We will in particular stress the features and reasons that lead DFT to become the dominant method for simulating quantum mechanical systems.

## 2. Course Size and Credits:

| | |
|---|---|
| Number of credits | 5 |
| Credit Structure (Lecture: Tutorial: Practical) | 3:1:1 |
| Total hours of interaction | 60 + 30 |
| Number of Weeks in a Semester | 15 |
| Department responsible | Physics |
| Total Course Marks | 100 |
| Pass requirement | As per the Academic Regulations |
| Attendance requirement | As per the Academic Regulations |

## 38. Course Objectives (CO)

After the successful completion of this course, the student will be able to:

**CO - 1** Explain basics of vector spaces and subspaces, elements of computational techniques, importance sampling, mathematical and early approximations, and rigorous foundation on density functional theory.

**CO - 2** Discuss various numerical techniques and how they are used to obtain approximate solutions to intractable physical problems.

**CO - 3** Describe the concepts/methods of Kinetic Monte Carlo, Monte Carlo simulation of statistical physics ensembles, Simulated annealing and Quantum Monte Carlo, Hohenberg–Kohn Variational theorem and their applications, Kohn–Sham self-consistent field methodology.

**CO - 4** Solve problems based on various numerical techniques and different Monte Carlo based methods.

**CO - 5** Write and execute appropriate programs on numerical analysis using Python.

## 39. Course Contents

**Linear vector spaces and operators:** Vector spaces and subspaces, Linear dependence and independence, Inner product, Orthogonality, Gramm-Schmidt orthogonalization procedure, Basis and Dimensions, Linear operators, Matrix representation, Similarity transformations, Characteristic polynomial of a matrix, Eigen values and eigenvectors, Self-adjoint adjoint and

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Unitary transformations, Eigen values and Eigen vectors of Hermitian and unitary transformations, Minimal polynomial and diagonalization.

**Numerical Techniques:** Elements of computational techniques: root of functions (a) Newton-Raphson method and (b) bisection method, Interpolation, Extrapolation, Integration by trapezoid and Simpson's rule, Solution of first order differential equation using Runge Kutta method, Finite difference methods. Introductory group theory: SU(2), O(3).

**Monte Carlo simulations:** Importance Sampling, The metropolis methods, Basic Monte Carlo algorithm, Technical details of Monte Carlo algorithm, Detailed balance versus balance, Monte Carlo simulations in various ensembles (Canonical, micro-canonical and grand-canonical ensembles).

Molecular dynamics simulations: Initialization, The force calculation, Integrating the equations of motion, Molecular dynamics simulations in various ensembles (Canonical, micro-canonical and grand-canonical ensembles).

**Density functional theory:** Theoretical motivation, Philosophy, Early Approximations, Rigorous Foundation, The Hohenberg–Kohn existence theorem, The Hohenberg–Kohn Variational theorem, Kohn–Sham self-consistent field methodology, Exchange-correlation functional, Local density approximation, Density gradient and Kinetic energy density corrections, Adiabatic connection methods, Semi-empirical DFT, Advantages and disadvantages of DFT compared to MO theory, Densities vs. Wave functions, Computational efficiency, Limitations of the KS formalism.

**Experiments:**
Writing and Execution of programs based on computational and numerical techniques using python programming.

## 40. Course Map (CO-PO-PSO Map)

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 2 | 2 | 3 | | 2 | | | | | | 3 | 2 | |
| CO-2 | 2 | 2 | 2 | | | | | | | | 2 | | |
| CO-3 | 1 | 1 | 2 | | 1 | | | | | | 2 | 1 | |
| CO-4 | 3 | 2 | 2 | | | | | | 2 | 1 | 3 | | 2 |
| CO-5 | 2 | | 1 | | | | | | | | 2 | | |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

## 41. Course Teaching and Learning Methods

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| Face to Face Lectures | | 40 |
| Demonstrations | | 05 |
| 7. Demonstration using videos | 2 | |
| 8. Demonstration using physical models/systems | | |
| 3. Demonstration of computer aided models | 3 | |
| Numeracy | | 15 |
| 1. Solving numerical problems | 15 | |

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| Practical Work | | |
|---|---|---|
| 1. Course laboratory | 30 | 30 |
| 2. Computer laboratory | | |
| 3. Engineering workshop/course | | |
| 4. Clinical laboratory | | |
| 5. Hospital | | |
| 6. Model studio | | |
| **Others** | | |
| 1. Case study presentation | | |
| 2. Guest lecture | | |
| 3. Industry/Field visit | | |
| 4. Brain storming sessions | | |
| 5. Group discussions | | |
| 6. Discussing possible innovations | | |
| Term Tests and written examination | | 10 |
| Total duration in hours | | 100 |

**42. Course Assessment and Reassessment**

The details of the components and subcomponents of course assessment is presented in the programme specifications document pertaining to the M.Sc. in Physics programme. The procedure to determine the final course marks is also presented in the programme specifications document.

Course reassessment policies are presented in the Academic Regulations document.

**17 Achieving COs**

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No. | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Class room lectures |
| 2. | Understanding | Class room lectures, and demonstrations |
| 3. | Critical Skills | Assignment |
| 4. | Analytical Skills | Class room, assignment |
| 5. | Problem Solving Skills | Class room, assignment |
| 6. | Practical Skills | Class room, assignment |
| 7. | Group Work | Class room |
| 8. | Self-Learning | Assignment |
| 9. | Written Communication Skills | Assignment, examination |
| 10. | Verbal Communication Skills | Presentation |
| 11. | Presentation Skills | Presentation |
| 12. | Behavioral Skills | Course |
| 13. | Information Management | Assignment, examination |
| 14. | Personal Management | Assignment, examination |
| 15. | Leadership Skills | Effective management of learning, time management, achieving the learning outcomes |

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**26. Course Resources**

**a. Essential Reading**


1. Mathematical methods of Physics, J Mathews and RL Walker, 2nd Edition, Addison-Wesley, 2003.
2. Mathematical Physics with Applications, Problems and Solution, V. Balakrishnan, Ane Books, 2017.
3. Mathematical Methods in the Physical Sciences, Mary L Boas, Wiley, New York, 1983.
4. Programming in ANSIC, E. Balaguruswamy, 2nd Edition, Tata McGraw Hill, 1992.
5. Lecture notes athttp://www.cplusplus.com/doc/tutorial/
6. Computational Physics Course athttp://www.phys.unsw.edu.au/~mcba/phys2020/#numi


**b. Recommended Reading**


4. Mathematical methods for Physicists, GB Arfken and H Weber, 7th Edition, Academic Press, 2012.
5. Mathematical Physics, PK Chattopadhyay, Wiley Eastern Ltd.1990.
6. Understanding Molecular Dynamics: From algorithms to Applications
7. Density Functional Theory: A Practical Introduction


**c. Magazines and Journals**

**c. Websites**

1. Physics Teacher Resources-aip.org

**d. Other Electronic Resources**

1. YouTube physics lectures
2. YouTube physics experiments

27. **Course Organization**

| | | |
|---|---|---|
| **Course Code** | PYC611A | |
| **Course Title** | Numerical Techniques, Computational Physics and Laboratory | |
| **Course Leader/s Name** | As per time table | |
| **Course Leader Contact Details** | **Phone:** | 080-4906 5555 |
| | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | 14 July 2022 | |
| **Next Course Specifications Review Date:** | July 2024 | |

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**Course Specification:** Quantum Mechanics -2

| | |
|---|---|
| Course Title | Quantum Mechanics - 2 |
| Course Code | PYC612A |
| Course Type | Core Theory Course |
| Department | Physics |
| Faculty | Faculty of Mathematical and Physical Sciences |

**8. Course Summary**

Quantum mechanics is one of the foundational theories on which modern physics rests. This course covers approximate methods for stationary and time dependent problems. This is followed by key elements of symmetry principles and conservation laws. These concepts are initially introduced and reinforced through relatively simple problems with analytic solutions, but computational solutions are also examined where appropriate. The course also covers theory including Dirac equation.

**9. Course Size and Credits:**

| | |
|---|---|
| Number of credits | 4 |
| Credit structure (Lecture: Tutorial: Practical) | 3:1:0 |
| Total hours of interaction | 60 |
| Number of weeks in a semester | 15 |
| Department responsible | Physics |
| Total course marks | 100 |
| Pass requirement | As per academic regulations |
| Attendance requirement | As per academic regulations |

**10. Course Objectives**

After the successful completion of this course, the student will be able to:

**CO - 1** Explain the basic concepts of Stationery and time dependent approximation methods, Symmetries and conservation laws and relativistic problems.

**CO - 2** Describe the major results of Stationery and time dependent approximation methods, Symmetries and conservation laws and relativistic problems

**CO - 3** Derive the major equations governing Stationery and time dependent approximation methods, Symmetries and conservation laws and relativistic problems

**CO - 4** Solve problems on Stationery and time dependent approximation methods, Symmetries and conservation laws and relativistic problems.

**CO - 5** Apply the results of Stationery and time dependent approximation methods, Symmetries and conservation laws and relativistic problems to relavant examples.

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## 11. Course Contents

**Approximation Methods for stationary problems:** Time independent perturbation theory: Time independent perturbation theory for non-degenerate and degenerate energy levels, applications: one dimensional harmonic oscillator subjected to a perturbing potential in x and x2, the fine structure of the hydrogen atom and Zeeman effect. Variational Method: Bound states (Ritz Method), Expectation value of the energy, Applications: Ground state of harmonic oscillator, ground state of Helium. WKB approximation: the classical region, connection formulae, alpha decay and tunneling.

**Approximation Methods for time dependent problems:** Time dependent perturbation theory: Approximate solution of the Schrodinger equation with time dependent Hamiltonian, constant perturbation, harmonic perturbation, transition to a continuum, transition probability and Fermi golden rule. Quantum Collision Theory: The scattering experiment, relationship of the scattering cross section to the wave function, scattering amplitude and scattering cross-section, Integral equation of potential scattering, Born approximation, scattering by a spherically symmetric potential, cross-section for scattering in a screened coulomb potential. Method of partial waves: Expansion of a plane wave in terms of partial waves, scattering by a central potential, optical theorem.

**Symmetry Principles and Conservation Laws:** Continuous symmetries: Spatial translation symmetry and conservation of linear momentum, time translation symmetry and conservation in energy, Rotations in Space: Conservation of angular momentum. Discrete symmetries: Parity, Time reversal, Permutation symmetry, symmetric and antisymmetric wave functions, Slater determinant, ortho and para helium, scattering of identical particles. Three dimensional problems: Spin 1/2 particles in a box – The Fermi gas.

**Relativistic quantum mechanics:** Klein-Gordon equation for a free relativistic particle, Plane wave solutions, probability density and probability current density. Dirac Hamiltonian for a free relativistic particle, properties of alpha and beta matrices, probability density and probability current, positive and negative energy solutions, orthogonality and completeness of the solutions, intrinsic spin of the Dirac particle, Negative energy sea, gamma matrices, covariant form of Dirac equation, Non-relativistic approximation of Dirac equation in the presence of central potential and spin-orbit energy, Dirac particle in an external magnetic field, magnetic moment.

## 12. Course Map (CO-PO-PSO Map)

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 3 | 3 | | | | | | | 1 | 2 | 3 | | 2 |
| CO-2 | 3 | 3 | | | | | | | | 2 | 3 | | 2 |
| CO-3 | 3 | 3 | 2 | | 2 | | | | 1 | 2 | 3 | 2 | 2 |
| CO-4 | 3 | 3 | 2 | | 2 | | | | | 2 | 3 | 2 | 2 |
| CO-5 | 3 | 3 | 2 | | 2 | | | | | 2 | 3 | 2 | 2 |

## 13. Course Teaching and Learning Methods

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| Face to Face Lectures | | 40 |
| Demonstrations | | |
| 1. Demonstration using Videos | | |



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| | | |
|---|---|---|
| 2. Demonstration using Physical Models / | | |
| 3. Demonstration on a Computer | 5 | |
| **Numeracy** | | 15 |
| 1. Solving Numerical Problems | 10 | |
| **Practical Work** | | 00 |
| 1. Course Laboratory | | |
| 2. Computer Laboratory | | |
| 3. Engineering Workshop / Course Workshop / Kitchen | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | 00 |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry / Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| Term Tests, Written Examination | | 10 |
| Total Duration in Hours | | 70 |

**14. Course Assessment and Reassessment**

The details of the components and subcomponents of course assessment is presented in the Programme Specifications document pertaining to the M.Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document.

**18 Achieving COs**

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No. | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Classroom lectures |
| 2. | Understanding | Class room lectures, and demonstrations |
| 3. | Critical Skills | Assignment |
| 4. | Analytical Skills | Class room, assignment |
| 5. | Problem Solving Skills | Class room, assignment |
| 6. | Practical Skills | Class room, assignment |
| 7. | Group Work | Classroom |
| 8. | Self-Learning | Assignment |
| 9. | Written Communication Skills | Assignment, examination |
| 10. | Verbal Communication Skills | Presentation |
| 11. | Presentation Skills | Presentation |
| 12. | Behavioral Skills | Course |
| 13. | Information Management | Assignment, examination |

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| | | |
|---|---|---|
| 14. | Personal Management | Assignment, examination |
| 15. | Leadership Skills | Effective management of learning, time management, achieving the learning |

**28. Course resources**

**f. Essential Reading**

z. Class Notes
aa. Griffiths D.J. (2004) Introduction to Quantum Mechanics, Third Edition, Pearson Education
bb. Liboff.(2007) Introductory Quantum Mechanics, 4th Edition, Pearson Education Ltd.
cc. Arul Das. (2000) Quantum Mechanics, Prentice Hall of India.
dd. Ghatak A. K. & Lokanathan S., (1997) Quantum Mechanics, McMillan India Ltd.

**g. Recommended Reading**

1. Schiff L. I. (1968) Quantum Mechanics, McGraw Hill Publishers.
2. Sakurai (2002) Modern Quantum Mechanics, Pearon Education Asia.
3. Crasemann B. & Powell J. H., (1988) Quantum Mechanics, Narosa Publishing House.
4. Feynman R. P, Leighton R. B. & Matthew Sands., (1966) The Feynman Lectures on Physics, Vol. III, Addison-Wesley Publishing Company, Inc.

**h. Magazines and Journals**

1. The Physics Teacher published by the American Physical Society
2. American Journal of Physics published by the American Physical Society
3. Contemporary Physics published by the Institute of Physics
4. Resonance published by the Indian Academy of Sciences

**i. Websites**

6. http://nptel.ac.in/

**j. Other Electronic Resources**

a. Youtube quantum mechanics lectures

29. **Course Organization**

| | | | |
|---|---|---|---|
| **Course Code** | PYC612A | | |
| **Course Title** | Quantum mechanics - 2 | | |
| **Course Leader/s Name** | | As per Time - table | |
| **Course Leader Contact Details** | | **Phone:** | +91-804-906-5555 |
| | | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | | 14 July 2022 | |
| **Next Course Specifications Review Date** | | July 2024 | |

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**Course Specifications:** Nuclear and Particle Physics

| | |
|---|---|
| Course Title | Nuclear and Particle Physics |
| Course Code | PYC613A |
| Course type | Core Theory Course |
| Department | Physics |
| Faculty | Mathematical and Physical Sciences |

## 1. Course Summary

In this course the students are introduced to the structure and properties of atomic nucleus with the help of various nuclear models. They are taught about the strong, weak and electromagnetic forces which result in nuclear decay. The nuclear decay is explained on the basis of quantum mechanical ideas. The interaction of alpha, beta and gamma rays with matter and the utility of different types of particle detectors are described. Students will also be introduced to the various elementary particles. Different types of interaction between the particles will be discussed.

## 2. Course Size and Credits:

| | |
|---|---|
| **Number of credits** | 04 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 3:1:0 |
| **Total hours of Interaction** | 60 |
| **Number of Weeks in a Semester** | 15 |
| **Department responsible** | Physics |
| **Total Course Marks** | 100 |
| **Pass requirement** | As per the Academic Regulations |
| **Attendance requirement** | As per the Academic Regulations |

## 43. Course Objectives (CO)

After the successful completion of this course, the student will be able to:

- **CO - 1** Explain general properties of nucleus, Nuclear Interactions, Detectors and Accelerators, Nuclear Techniques and describe the classification of elementary particles
- **CO - 2** Analyze the structure of nucleus and various nuclear models and derive the important relations in nuclear and particle physics
- **CO - 3** Discuss the various nuclear models and decay modes.
- **CO - 4** Apply the data measurement techniques with detectors
- **CO - 5** Solve problems on nuclear properties, nuclear models, nuclear decay modes, accelerators and particle physics

## 44. Course Contents

**Nuclear Constituents and Characteristics:**
Size of the nucleus, Nuclear Mass, Nuclear Binding Energy, Nuclear radius, Spin and magnetic moments of Nuclei, Schmidt limits, parity, Angular Moment, Electric Quadruple moments. Methods of investigating nuclear size - Mesonic X-rays and Electron scattering.



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**Nuclear structure models:**
Liquid drop model, Bohr-Wheeler theory of fission, Fermi-gas model, Nuclear shell model, Experimental evidence for shell effects, Shell model, Spin orbit coupling Magic numbers , Angular momenta and parities of nuclear ground states.

**Nuclear Interactions:**
Strong, Weak and Electromagnetic forces-Alpha decay-kinematics of alpha decay-penetration through coulomb barrier-alpha spectroscopy, Beta decay- Neutrino hypothesis-Dynamics of beta decay, Gamma decay-classical theory of radiation kinematics of photon emission-, Multipole transitions in nuclei , Angular momentum and parity selection rules , Internal conversion , lifetimes for gamma emission.

**Detectors and Accelerators in Nuclear Physics:**
Interaction of radiation with matter and radiation detection: Interaction of heavy charged particles, neutrons, gamma rays and relativistic particles. Radiation Detection mechanism, characteristics of detectors.
Gas detectors, scintillation counters, solid state detectors. Van de Graff, LINAC, Cyclotrons, Synchrotrons, Colliders.

**Nuclear Techniques:**
Neutron Activation Analysis – Rutherford backscattering (RBS) technique, Nuclear Magnetic Resonance, Mossbauer spectroscopy, Positron annihilation technique – applications.

**Particle Physics:**
Elementary particles and their classifications. Types of interaction between elementary particles, Hadrons and leptons, Symmetry and conservation laws, Elementary ideas of CP and CPT invariance, Classification of hadrons, Lie algebra, SU (2) - SU (3) multiplets, Quark model, Gell - Mann - Okuba mass formula for octet and decaplet hadrons, Charm, bottom and top quarks. Unification of weak and electromagnetic interaction – LIGO experiment.

**45. Course Map (CO-PO-PSO Map)**

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 3 | 2 | 2 | 1 | 2 | | | | | | 3 | 2 | |
| CO-2 | 2 | 2 | 2 | 2 | 2 | | | | | | 2 | 2 | |
| CO-3 | 3 | 1 | 2 | 2 | 1 | | | | | | 3 | 2 | |
| CO-4 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | | | | 3 | 2 | 2 |
| CO-5 | 2 | 1 | 2 | 1 | 1 | | | | | | 2 | 1 | |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

**46. Course Teaching and Learning Methods**

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| Face to Face Lectures | | 42 |
| Demonstrations | | 03 |
| 1. Demonstration using Videos | 02 | |
| 2. Demonstration using Physical Models / | | |
| 3. Demonstration on a Computer | 01 | |

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| | | |
|---|---|---|
| **Numeracy** | | 15 |
| 1. Solving Numerical Problems | 15 | |
| **Practical Work** | | 00 |
| 1. Course Laboratory | | |
| 2. Computer Laboratory | | |
| 3. Engineering Workshop / Course Workshop / Kitchen | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | 00 |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry / Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| Term Tests, Written Examination | | 10 |
| | Total Duration in Hours | 70 |

**47. Course Assessment and Reassessment**

The details of the components and subcomponents of course assessment is presented in the Programme Specifications document pertaining to the M.Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document. Course reassessment policies are presented in the Academic Regulations document.

**19 Achieving COs**

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No. | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Classroom lectures |
| 2. | Understanding | Class room lectures, and demonstrations |
| 3. | Critical Skills | Assignment |
| 4. | Analytical Skills | Class room, assignment |
| 5. | Problem Solving Skills | Class room, assignment |
| 6. | Practical Skills | Class room, assignment |
| 7. | Group Work | Classroom |
| 8. | Self-Learning | Assignment |
| 9. | Written Communication Skills | Assignment, examination |
| 10. | Verbal Communication Skills | Presentation |
| 11. | Presentation Skills | Presentation |
| 12. | Behavioral Skills | Course |
| 13. | Information Management | Assignment, examination |

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| | | |
|---|---|---|
| 14. | Personal Management | Assignment, examination |
| 15. | Leadership Skills | Effective management of learning, time management, achieving the learning outcomes |

**30. Course Resources**

**ee. Essential Reading**


1. Class Note
2. Krane, K.S. (October 1987) Introductory nuclear Physics, Wiley.
3. Cohen, B.L. (1988) Concepts of Nuclear Physics, McGraw Hill, revised Ed.
4. Griffiths, D. (1987) Introduction to Elementary Particles, NY, Harper Row.
5. John .M. Blatt & Victor S Weisskopf (1991) Theoretical Nuclear Physics, Dover Publications, Inc.


**ff. Recommended Reading**


1. Wong, S.S.M. (1990) Introductory Nuclear Physics, Prentice Hall.
2. Brian Martin, (2009) Nuclear and Particle Physics –An introduction, 2nd edition, Wiley
3. John S. Lilley, (2001) Nuclear Physics - Principles and Applications, Wiley.
4. Kaplan, I. (1989) Nuclear Physics, 2nd Ed. New Delhi, Narosa.
5. Leo, W. R. (1994) Techniques for Nuclear and Particle Physics Experiments, Springer Verlag.


**gg. Magazines and Journals**

Journal of Nuclear Physics

**hh. Websites**

http://science.energy.gov/np/

http://www.eps.org

**ii. Other Electronic Resources**

www.nptel.ac.in

31. **Course Organization**

| | | | |
|---|---|---|---|
| **Course Code** | PYC613A | | |
| **Course Title** | Nuclear and Particle Physics | | |
| **Course Leader/s Name** | | As per Time - table | |
| **Course Leader Contact Details** | | **Phone:** | +91-804-906-5555 |
| | | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | | 14 July 2022 | |
| **Next Course Specifications Review Date** | | July 2024 | |

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## Course Specifications: Advanced Solid-State Physics and Laboratory

| | |
|---|---|
| Course Title | Advanced Solid-State Physics and Laboratory |
| Course Code | PYC631A |
| Course Type | Core Theory Course |
| Department | Physics |
| Faculty | Mathematical and Physical Sciences |

### 1. Course Summary

This course has the theme to cover many other properties of crystals. The aim of this course is to enable the students to understand the electrical, optical and magnetic properties of crystals. The relation between crystal structure and the electrical, magnetic and optical properties of crystals is discussed. The application of quantum mechanics in explaining these properties is highlighted.

### 2. Course Size and Credits:

| | |
|---|---|
| **Number of credits** | 05 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 3:1:1 |
| **Total hours of interaction** | 60 + 30 |
| **Number of Weeks in a Semester** | 15 |
| **Department responsible** | Physics |
| **Total Course Marks** | 100 |
| **Pass requirement** | As per the Academic Regulations |
| **Attendance requirement** | As per the Academic Regulations |

### 48. Course Objectives (CO)

After the successful completion of this course, the student will be able to:

**CO - 1** Explain the basic concepts of Imperfections in Crystals, dielectric, Magnetic Materials, and nanoscience

**CO - 2** Describe mechanism and properties of Imperfections in Crystals, dielectric, Magnetic Materials, and nanoscience

**CO - 3** Solve problems on lasers, spin resonance, atomic and molecular physics

**CO - 4** Discuss the applications of Imperfections in Crystals, dielectric, Magnetic Materials, and nanoscience

**CO - 5** Conduct appropriate experiments based on solid state physics and nanoscience as per the standard procedures and tabulate the measured values and analyze the results

### 49. Course Contents

**Imperfections in Crystals**

Point defects, Schottky and Frenkel defects, Line defects, edge dislocations, screw dislocation, Burgers vector, surface defects, tilt and twin boundaries, grain boundaries and volume defects in crystals-Mechanical properties of Crystals-Stress and strain tensors-Elastic constants of crystals- Plastic deformation-Anelasticity-Viscoelastic behavior- Effect of grain structure and processing conditions on mechanical properties such as elastic moduli, strength, toughness etc.

**Dielectrics:**



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Introduction, Review of basic formulae, Dielectric constant and displacement vector -different kinds of polarization-local electric field-Lorentz field- Clausius Mossotti equation relation-expressions for electronic, ionic and dipolar polarizability, dielectric in alternating field, complex dielectric constant and dielectric loss, energy dissipation, dielectric strength, ferroelectricity, dipole theory of ferroelectricity, piezoelectricity and pyroelectricity- Their use as sensors, memories and insulators.

**Magnetic Materials:**

Introduction, classification of magnetic material, atomic theory of magnetism, quantum numbers, origin of permanent magnetic moments, classical and quantum theory of diamagnetism, para-magnetism and ferromagnetism, Weiss molecular field, Curie-Weiss law, ferromagnetic domains, domain theory, materials for hard and soft magnets-Design of magnets-GMR and CMR materials- Materials for magnetic memories-Magneto-optic technology for information storage-Magnetostriction based ultrasonic generators.

**Introduction to nanoscience**

Definition, reason for interest in nanomaterials, classification of nanostructures – 1D, 2D and 3D confinement. Dimensionality and size dependent phenomena, Properties at nanoscale (optical, mechanical, electronic and magnetic), scaling law, density of states in quantum well, wire and dots, graphene, fullerenes and carbon nanotube.

**Characterization of nanomaterials**:

X-ray Diffraction (XRD) – Crystallinity, particle/crystallite size determination and structural analysis. Microscopic techniques: Scanning Electron Microscopy (SEM)–Morphology, grain size and EDX; Transmission Electron Microscopy (TEM) – Morphology, particle size and electron diffraction, Selected Area Electron Diffraction (SAED). Scanning probe techniques: Scanning Tunneling Microscopy (STM) – surface imaging and roughness; Atomic Force Microscopy (AFM) - surface imaging and roughness; spectroscopic techniques: UV-visible, other technique: X-ray Photoelectron Spectroscopy (XPS), Thermal gravimetric analysis (TGA), Differential thermal analysis (DTA), differential scanning calorimetry. (Qualitative).

## 50. Course Map (CO-PO-PSO Map)

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 3 | 2 | 2 | 2 | 2 | | 1 | | | 1 | 3 | 1 | |
| CO-2 | 3 | 2 | 2 | 2 | 1 | | 1 | | | 1 | 2 | 2 | |
| CO-3 | 1 | 3 | 1 | 2 | 2 | | | 1 | | 1 | 2 | 1 | |
| CO-4 | 2 | 3 | 1 | 1 | 2 | | | | | 1 | 2 | 2 | |
| CO-5 | 3 | 3 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 2 |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

## 51. Course Teaching and Learning Methods

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| Face to Face Lectures | | 42 |
| Demonstrations | | 03 |
| 9. Demonstration using Videos | 1 | |



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| | | |
|---|---|---|
| 10. Demonstration using Physical Models/Systems | | |
| 3. Demonstration on a Computer | 2 | |
| **Numeracy** | | 15 |
| 1. Solving Numerical Problems | 15 | |
| **Practical Work** | | 30 |
| 1. Course Laboratory | 30 | |
| 2. Computer Laboratory | | |
| 3. Engineering Workshop/Course | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry/Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| Term Tests and Written Examination | | 10 |
| Total Duration in Hours | | 100 |

**52. Course Assessment and Reassessment**

The details of the components and subcomponents of course assessment is presented in the Programme Specifications document pertaining to the M.Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document. Course reassessment policies are presented in the Academic Regulations document.

**20 Achieving COs**

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No. | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Classroom lectures |
| 2. | Understanding | Class room lectures, and |
| 3. | Critical Skills | Assignment |
| 4. | Analytical Skills | Class room, assignment |
| 5. | Problem Solving Skills | Class room, assignment |
| 6. | Practical Skills | Class room, assignment |
| 7. | Group Work | Classroom |
| 8. | Self-Learning | Assignment |
| 9. | Written Communication Skills | Assignment, examination |
| 10. | Verbal Communication Skills | Presentation |
| 11. | Presentation Skills | Presentation |
| 12. | Behavioral Skills | Course |
| 13. | Information Management | Assignment, examination |
| 14. | Personal Management | Assignment, examination |

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| | | |
|---|---|---|
| 15. | Leadership Skills | Effective management of learning, time management, achieving the learning |

**32. Course Resources**

**k. Essential Reading**

22. Class Notes
23. Kittel, C. (2004) Introduction to Solid State Physics, 7th Edn, John Wiley.
24. S. O. Pillai, (2021) Solid States Physics, New age international publishers, New Delhi
25. Aschcroft N.W & Mermin N.D., (1976) Solid State Physics, Saunders College Publishing, Harcourt Brace College publishers, New York.
26. Pradeep T., (2012) A Textbook of Nanoscience and Nanotechnology, New Delhi: Tata McGraw Hill Education Pvt. Ltd
27. Poole, C.P. Jr. and Owens, F.J., (2008) Introduction to Nanotechnology, India: Wiley-India edition.

**l. Recommended Reading**

1. Callister W.D. (1997) Materials Science and Engineering-An Introduction, New York: John Wiley.
2. Smith W.F. (1990) Principles of Materials Science and Engineering, McGraw Hill.
3. Phillips F.C. (1963) An introduction to Crystallography, ELBS, London.
4. Srinivasan, M. R. (2009) Applied Solid State Physics, New Delhi: New Age International Publishers
5. Chemistry of Nanomaterials: Synthesis, Properties and Applications - CNR Rao, H.C. mult. Achim Müller, A. K. Cheetham, Wiley-VCH Verlag GmbH & Co. KGaA, ISBN: 9783527306862, 9783527602476, 2004.
6. Guozhong Cao, (2004)Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press
7. Hari Singh Nalwa, (2002) Nanostructured Materials and Nanotechnology, Cambridge: Academic Press. Spiegel

**m. Magazines and Journals**

1. The Physics Teacher published by the American Physical Society
2. American Journal of Physics published by the American Physical Society
3. Contemporary Physics published by the Institute of Physics
4. Resonance published by the Indian Academy of Sciences

**n. Websites**

3. Physics Teacher Resources-aip.org

**o. Other Electronic Resources**

5. http://nptel.ac.in/
6. Youtube physics lectures

**33. Course Organization**

| | | | |
|---|---|---|---|
| **Course Code** | PYC631A | | |
| **Course Title** | Advanced Solid-State Physics and Laboratory | | |
| **Course Leader/s Name** | | As per time table | |
| **Course Leader Contact Details** | | **Phone:** | 080 4906 5555 |
| | | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | | 14 July 2022 | |
| **Next Course Specifications Review Date:** | | July 2024 | |

Faculty of Mathematical and Physical Sciences

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**Course Specification:** Nuclear Physics, Nuclear Electronics and Applications

| Course Title | **Nuclear Physics, Nuclear Electronics and Applications** |
|---|---|
| Course Code | PYC641A |
| Course Type | Core Theory and Experiments Course |
| Department | Physics |
| Faculty | Faculty of Mathematical and Physical Sciences |

**1. Course Summary**

This course deals with advanced nuclear physics principles and models. Description of the nucleon-nucleon interactions with spin dependence and the deuteron bound state is given. Collective models and scattering theory is introduced. Compound nuclear, direct reaction and optical models are explained. Resonances and the Breit-Wigner expression for resonance cross sections presented. Elements of nuclear astrophysics is introduced. The electronics of nuclear instruments and the detectors with emphasis on the principles of operation of various components contained in the instrument. The various techniques used for pulse height analysis is covered. The idea of counting statistics is also discussed. The module also deals with nuclear medicine in clinical diagnosis and treatment.

**2. Course Size and Credits:**

| | |
|---|---|
| **Number of credits** | 05 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 3:1:1 |
| **Total hours of interaction** | 60 + 30 |
| **Number of Weeks in a Semester** | 15 |
| **Department responsible** | Physics |
| **Total Course Marks** | 100 |
| **Pass requirement** | As per the Academic Regulations |
| **Attendance requirement** | As per the Academic Regulations |

**3. Course Objectives**

After the successful completion of this course, the student will be able to:

**CO - 1** Explain the basic concepts of nucleon-nucleon interactions, collective models, Reaction models, nuclear astrophysics, nuclear electronics and nuclear medicine

**CO - 2** Describe nucleon forces and various models of nuclear structure and reactions. Explain elements of nucleosynthesis
Describe electronics of components and functions of detector systems.
Discuss applications of radioisotopes in the treatment of cancer.
Describe role of nuclear medicine in dentistry and pediatrics and thyroid disorders.

**CO - 3** Solve problems on nucleon interactions, nuclear structure and reaction models, nuclear electronics and medicine

**CO - 4** Discuss the applications of nuclear models, nuclear electronics and radioisotopes in nuclear reactors, accelerator driven systems, astrophysics and nuclear medicine.

**CO - 5** Perform appropriate experiments as per the standard procedures and tabulate the measured values and analyze the results



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## 4. Course Contents

**Nuclear force and two nucleon problem:**

Deuteron and its simple theory, range and depth of the potential, excited states of deuteron. n-p scattering at low energies, phase shift analysis, scattering length, spin dependence of the nuclear forces, equivalence of p-p and n-p singlet forces, equivalence of n-n and p-p forces, exchange forces, evidence for the existence of non-central forces, discussion on Yukawa's theory.

**Nuclear Structure and reactions:**

Shell model - Collective models of motion-nuclear vibrations-rotational –Nilsson model- Types of reactions and conservation laws, Energetics of nuclear reactions, Dynamics of nuclear reactions, Q value equation, Scattering and reaction cross sections

Partial wave analysis of nuclear reactions Expression for reaction and scattering cross sections and their interpretation, shadow scattering, resonance theory of scattering and absorption, Breit Wigner formula for scattering and reaction, Shape of cross section near resonance

Compound nucleus reactions, Direct reactions, Resonance scattering, Breit-Wigner one level formula, Direct interaction Mechanisms, Angular distribution in stripping, pick up and inelastic scattering reactions , Spin, parity assignments , Total neutron cross sections. Gross structure problem, Optical model and its explanation of gross structure problem.

Nuclear Astrophysics: Primordial nucleon synthesis, energy production in stars, pp chain, CNO cycle. Production of elements.

**Nuclear Electronics:**

Analog and digital electronics for detectors: components and functions of detector system detection limits and resolution, Pulse Processing and shaping: Preamplifiers - Voltage, Current and Charge sensitive types. Resistive and Optical feedback. Main amplifiers- pulse shaping, pole-zero compensation, base line restoration and pile up rejection. Pulse height analysis: Single Channel analyser – integral and differential modes of operation. Simple spectrometer assembly

**Multi-channel analyzer:**

A/D converters (Wilkinson and Flash types). D/A converters (R-2R ladder type). Principle of operation and performance indices. Multi-channel analyser in PHA and MCS modes. Coincidence measurements: Slow - fast coincidence arrangement for measurement of coincidence between radiations. Prompt and chance coincidences. Experimental arrangement for energy and time coincidence measurements. Counting Statistics: Statistical errors and their propagation in experimental measurements, $\chi$-test.

**Nuclear Medicine:**

Review of units of radiation measurement, interaction of radiation with matter, attenuation of gamma rays, gas filled and scintillation detectors. Structure of the living cell – cell division – direct and indirect action of ionizing radiation – Biological effects of radiations – somatic and genetic effect ,radiotracers, Patient dosimetry- MIRD calculations, S- factor, typical nuclear medicine doses, typical doses in X-ray CT

Applications of radio isotopes in medicine – use of radio isotopes for the study of the thyroid , diagnosis and treatment of cancer, radiation therapy , role of nuclear medicine in dentistry , pediatric nuclear medicine.

Lab Experiments

1. Study of Cs-137 spectrum and calculation of FWHM and resolution for a given scintillation detector



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2. Study of energy resolution characteristics of a scintillation spectrometer as a function of applied high voltage
3. Endpoint energy of Beta particles using Fermi-Curie plot
4. Verification of inverse square law for gamma ray using gamma ray spectrometer
5. Statistics of counting
6. Estimation of efficiency of the GM detector for Gamma source and Beta source
7. To study the beta particle range and maximum energy (Feather Analysis)
8. Measurement of short half-life
9. Backscattering of Beta particles

## 5. Course Map (CO-PO-PSO Map)

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 3 | 3 | | | | | | | 1 | 1 | 3 | | 1 |
| CO-2 | 3 | 3 | 2 | 1 | 2 | | 1 | | 1 | 1 | 3 | 2 | 1 |
| CO-3 | 3 | 3 | 2 | | | | | | 1 | 1 | 3 | | 1 |
| CO-4 | 3 | 3 | | 1 | 2 | | | | 1 | 1 | 3 | 2 | 1 |
| CO-5 | 3 | 2 | 1 | | | | | | 1 | 1 | 3 | | 1 |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

## 6. Course Teaching and Learning Methods

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| **Face to Face Lectures** | | 42 |
| **Demonstrations** | | 03 |
| 1. Demonstration using Videos | 01 | |
| 2. Demonstration using Physical Models / Systems | | |
| 3. Demonstration on a Computer | 02 | |
| **Numeracy** | | 15 |
| 1. Solving Numerical Problems | 15 | |
| **Practical Work** | | 60 |
| 1. Course Laboratory | 30 | |
| 2. Computer Laboratory | | |
| 3. Engineering Workshop / Course Workshop | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | 00 |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry / Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| **Term Tests, Written Examination** | | 10 |
| | Total Duration in Hours | 100 |

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## 7. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment is presented in the Programme Specifications document pertaining to the M.Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document.

## 8 Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No. | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Classroom lectures |
| 2. | Understanding | Class room lectures, and demonstrations |
| 3. | Critical Skills | Assignment |
| 4. | Analytical Skills | Class room, assignment |
| 5. | Problem Solving Skills | Class room, assignment |
| 6. | Practical Skills | Class room, assignment |
| 7. | Group Work | Classroom |
| 8. | Self-Learning | Assignment |
| 9. | Written Communication Skills | Assignment, examination |
| 10. | Verbal Communication Skills | Presentation |
| 11. | Presentation Skills | Presentation |
| 12. | Behavioral Skills | Course |
| 13. | Information Management | Assignment, examination |
| 14. | Personal Management | Assignment, examination |
| 15. | Leadership Skills | Effective management of learning, time management, achieving the learning |

## 9. Course resources

### a. Essential Reading

1. Class Notes
2. Helmuth Spieler., (1998) Introduction to Radiation detectors and electronics.
3. Helmuth Spieler (2005) Semiconductor detector Systems — oxford university press.
4. Knoll, G. F. (2000) Radiation Detection and Measurement. – iii edition , John wiley & sons.
5. Keiran Maher , Basic Physics of Nuclear medicine, wiki books

### b. Recommended Reading

1. Stefan Tavernier , Radiation detectors for medical applications
2. Kapoor S. S & Ramamurthy, V. S. (1986) Nuclear Radiation Detectors, new age International.
3. Edmund Kim. E. Hand book of Nuclear Medicine and molecular imaging Principles and clinical applications



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**c. Magazines and Journals**

Journal of Nuclear Physics

**d. Websites**

1. http://nptel.ac.in/

**e. Other Electronic Resources**

1. http://science.energy.gov/np/
2. http://www.eps.org

10. **Course Organization**

| | | |
|---|---|---|
| **Course Code** | PYC641A | |
| **Course Title** | Nuclear Physics, Nuclear Electronics, Applications and Laboratory | |
| **Course Leader/s Name** | As per Time - table | |
| **Course Leader Contact Details** | **Phone:** | +91-804-906-5555 |
| | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | 14 July 2022 | |
| **Next Course Specifications Review Date** | July 2024 | |

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## **Course Specifications:** Research Methodology

| | |
|---|---|
| Course Title | Research Methodology |
| Course Code | MPF614A |
| Course Type | Core Theory Course |
| Department | Physics |
| Faculty | Mathematical and Physical Sciences |

### 11.Course Summary

The aim of the course is to introduce students to the principles of research, research methodology and significant phases of research.

Students are taught the significant role of Literature Review in a research cycle and the expectations from good literature review as well as procedure for systematic literature review. The essential aspects of technical communication to develop desirable writing skills for the preparation of research document including research paper as well as the skills for an effective presentation are also discussed. The module also emphasizes the desirable close knit relation between innovation and concept of out of the box thinking. Students will get an insight into the privilege, honour and the associated responsibilities of a researcher.

### 12. Course Size and Credits:

| | |
|---|---|
| **Number of Credits** | 02 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 2:0:0 |
| **Total Hours of Interaction** | 30 |
| **Number of Weeks in a Semester** | 15 |
| **Department Responsible** | Physics |
| **Total Course Marks** | 50 |
| **Pass Criterion** | As per the Academic Regulations |
| **Attendance Requirement** | As per the Academic Regulations |

### 13. Course Outcomes (COs)

After the successful completion of this course, the student will be able to:

**CO-1.** Describe the value, scope, relevance and mandatory steps of research as well as principles of effective research

**CO-2.** Discuss and demonstrate the application and utility of the Systematic approach and out of box thinking concepts for research to be effective

**CO-3.** Explain and apply the procedures outlined for a systematic Literature Review

**CO-4.** Outline the principles to prepare a well-structured research proposal and research paper invoking

**CO-5.** Identify and apply the essential skills desirable for an effective technical presentation

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## 14. Course Contents

**Foundations of Research:**

Definitions of Research, Mandatory Steps in Research, Types of Research, Relevance of Research for Innovation and Technology Development, Effective Research and Self Discipline. Out of the Box Thinking and Systematic approach in Research – Transformation to Impossible Thinking, Convergent and Divergent Thinking, Generation, Evaluation and Selection of Ideas

**Literature Review:**

Importance of Literature Review, Constituents of Good Literature Review, Strategies for Literature Search, Referencing, Paraphrasing, and Summarizing Academic Standards and Ethics. Statistical Methods and Data Analysis

**Research Proposal:**

Structure of a Good Research Proposal, Getting Started, Tips for

Compilation of Good Research Proposal. Technical Communication - Research Paper for Publication- Significance of Problem Statement and its scope, Formulation of Hypothesis, Adequacy of Methodology, Significance of Presentation and Discussion of Results, Relevance and Importance of references.

**Effective Presentation:**

Preparation, Templates, Balance between Good Design and Good Content, Planning and Sequencing, PAMPERS (Projection, Articulation, Modulation, Punctuation, Enunciation, Repetition and Speed) rule, PEOPLE (Position & Gestures, Eye Contact, Orientation, Proximation, Looks & Appearance, and Expressions & Emotion) rule, 4P's Rule (Plan, Prepare, Practice and Present), Essentials of Effectiveness, Effective Pausing and Inclusive Answering.

## 15. Course Map (CO-PO-PSO Map)

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 3 | | | | | | | | | | 3 | | |
| CO-2 | | | 3 | | 3 | | | | 3 | 3 | | 3 | |
| CO-3 | | | 3 | 3 | 3 | | | | 3 | 3 | | 3 | 3 |
| CO-4 | | | 3 | | 3 | | | | 3 | 3 | | 3 | 3 |
| CO-5 | | | | 3 | | | | | 3 | 3 | | 3 | 3 |

3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution

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## 16. Course Teaching and Learning Methods

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| **Face to Face Lectures** 35 | | 30 |
| **Demonstrations** | | 00 |
| 1.Demonstration using Videos | 00 | |
| 2. Demonstration using Physical Models / Systems | 00 | |
| 3. Demonstration on a Computer | 00 | |
| **Numeracy** | | 00 |
| 1. Solving Numerical Problems | 00 | |
| **Practical Work** | | 00 |
| 1. Course Laboratory | 00 | |
| 2. Computer Laboratory | 00 | |
| 3. Engineering Workshop / Course/Workshop / Kitchen | 00 | |
| 4. Clinical Laboratory | 00 | |
| 5. Hospital | 00 | |
| 6. Model Studio | 00 | |
| **Others** | | 00 |
| 1. Case Study Presentation | 00 | |
| 2. Guest Lecture | 00 | |
| 3. Industry / Field Visit | 00 | |
| 4. Brain Storming Sessions | 00 | |
| 5. Group Discussions | 00 | |
| 6. Discussing Possible Innovations | 00 | |
| Term Tests, Laboratory Examination/Written Examination, Presentations | | 05 |
| **Total Duration in Hours** | | **35** |

## 17. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M.Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (SC1, SC2, SC3 or SC4), COs are assessed as illustrated in the following Table.

| **Focus of COs on each Component or Subcomponent of Evaluation** | | |
|---|---|---|
| | **Component 1: CE (50 % Weightage)** | **Component 2: SEE (50 % Weightage)** |
| **Subcomponent ▶** | **SC1** | |
| **Subcomponent Type ▶** | **Assignment** | **50 Marks** |
| **Maximum Marks ▶** | **50** | |
| **CO-1** | | X |

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| | | |
|---|---|---|
| CO-2 | | X |
| CO-3 | X | X |
| CO-4 | X | X |
| CO-5 | | X |
| The details of SC1 are presented in the Programme Specifications Document. | | |

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

## 18. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Classroom lectures |
| 2. | Understanding | Classroom lectures, Self-study |
| 3. | Critical Skills | Assignment |
| 4. | Analytical Skills | Assignment |
| 5. | Problem Solving Skills | Assignment, Examination |
| 6. | Practical Skills | Assignment |
| 7. | Group Work | Group discussions, assignment |
| 8. | Self-Learning | Self-study |
| 9. | Written Communication Skills | Assignment, Examination |
| 10. | Verbal Communication Skills | -- |
| 11. | Presentation Skills | -- |
| 12. | Behavioral Skills | -- |
| 13. | Information Management | Assignment |
| 14. | Personal Management | -- |
| 15. | Leadership Skills | -- |

## 19. Course Resources

### b. Essential Reading

1. Class Notes
2. Booth, W. C, Colomb and G.G Williams., (2005) The Craft of Research, Chicago University Press, USA
3. Willium M.K and Trochim. (2003)Research Methods, 2nd Edition, Biztantra Publicshres, New Delhi
4. Jonathan Grix. (2004) The Foundation of Research, Palgrave Macmillan; Study Guide edition, USA

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**b. Recommended Reading**


1. Wisker Gina. (2001) The Post Graduate Research Handbook, , Palgrave Macmillan, USA.
2. Rugg G. and Petre M. (2004) The Unwritten Rules of Ph.D Research, Open University Press, UK


**c. Other Electronic Resources**

1. http://nptel.ac.in/

**20. Course Organization**

| | | | |
|---|---|---|---|
| **Course Code** | MPF614A | | |
| **Course Title** | Research Methodology | | |
| **Course Leader's Name** | | As per Timetable | |
| **Course Leader's Contact Details** | | **Phone:** | +91-804-906-5555 |
| | | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | | 14 July 2022 | |
| **Next Course Specifications Review Date** | | July 2024 | |

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**Course Specifications:** Advanced Physics Laboratory

| | |
|---|---|
| Course Title | Advanced Physics Laboratory |
| Course Code | PYL615A |
| Course Type | Laboratory Course |
| Department | Physics |
| Faculty | Mathematical and Physical Sciences |

**30. Course Summary**

This course intends to expose the students to the challenges and rewards related to experimental physics. Students gain hands-on experience by conducting experiments in a controlled laboratory environment. Students are trained to conduct experiments related to mechanics. They are trained to analyze the measurements, results and infer appropriate conclusions based on fundamental concepts of Physics.

**31. Course Size and Credits:**

| | |
|---|---|
| **Number of credits** | 02 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 0:0:2 |
| **Total hours of class room interaction** | 60 |
| **Number of semester weeks** | 16 |
| **Department responsible** | Physics |
| **Total Course marks** | 50 |
| **Pass requirement** | As per the Academic Regulations |
| **Attendance requirement** | As per the Academic Regulations |

**32. Course Outcomes (COs)**

After the successful completion of this course, the student will be able to:

CO - 1 Setup the experimental apparatus required to achieve the stated aim

CO - 2 Conduct experiments as per the standard procedures and tabulate the measured values

CO - 3 Calculate the required parameters and plot the results

CO - 4 Interpret and draw conclusions

CO - 5 Write laboratory report as per the prescribed format

**33. Course Contents**

1 To study the GM Characteristics

2 To verify the inverse square law

3 Endpoint energy of beta particles by half-thickness measurement

4 Measurement of Resolving (Dead) time

5 Dipole moment of an organic molecule, Acetone

6 Verification of Curie-Weiss law for ferroelectric material

7 Determination of R.I of transparent solid (PMMA) and liquid using TIR

8 Determination of R.I of liquid using TIR

9 B-H curve of a ferromagnetic material

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10 Hall effect

11 Zeeman effect

12 Study of characteristics of photodetectors

13 To study dark and illumination characteristics of pn junction solar cell and to determine its (i). Maximum power available (ii). Fill factor

14 To study the characteristics of light dependent resistor (LDR)

15 To study the characteristics of silicon controlled rectifier (SCR)

16 To determine dissociation energy from Iodine absorption spectrum

17 Analysis of Rotational and Vibrational spectrum

18 To study the GM Characteristics

19 To verify the inverse square law

20 Endpoint energy of beta particles by half-thickness measurement

21 Measurement of Resolving (Dead) time

**34. Course Map (CO-PO-PSO Map)**

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 2 | 2 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | | 3 | 2 | 2 |
| CO-2 | 2 | 1 | 3 | 2 | 1 | | 1 | | | | 3 | 2 | 1 |
| CO-3 | | | 3 | 1 | | | 1 | | | | 3 | 1 | 1 |
| CO-4 | 2 | 1 | 2 | 1 | 1 | | 1 | | | | 2 | 1 | 1 |
| CO-5 | 1 | | | | | | | | 2 | | 1 | | 2 |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

**35. Course Teaching and Learning Methods**

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| **Face to Face Lectures** | | • |
| **Demonstrations** | | 00 |
| 1. Demonstration using Videos | | |
| 2. Demonstration using Physical Models / Systems | | |
| 3. Demonstration on a Computer | | |
| **Numeracy** | | 00 |
| 1. Solving Numerical Problems | | |
| **Practical Work** | | 60 |
| 1. Course Laboratory | 60 | |
| 2. Computer Laboratory | | |
| 3. Engineering Workshop / Course Workshop | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |



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| Others | | |
|---|---|---|
| 1. Case Study Presentation | | 00 |
| 2. Guest Lecture | | |
| 3. Industry / Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| Term Tests, Laboratory Examination / Written Examination, Presentations | | 06 |
| Total Duration in Hours | | 66 |

**36. Course Assessment and Reassessment**

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M.Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document. Course reassessment policies are presented in the Academic Regulations document.

**37. Achieving Learning Outcomes**

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Laboratory instruction |
| 2. | Understanding | Laboratory instructions and experiments |
| 3. | Critical Skills | Laboratory work |
| 4. | Analytical Skills | Laboratory work |
| 5. | Problem Solving Skills | Laboratory work |
| 6. | Practical Skills | Laboratory work |
| 7. | Group Work | Laboratory work |
| 8. | Self-Learning | Laboratory work |
| 9. | Written Communication Skills | Laboratory work, examination |
| 10. | Verbal Communication Skills | Laboratory examination |
| 11. | Presentation Skills | -- |
| 12. | Behavioral Skills | Course work |
| 13. | Information Management | Laboratory work |
| 14. | Personal Management | Course work |
| 15. | Leadership Skills | -- |

**38. Course Resources**

n. **Essential Reading**

5. Laboratory manual
6. Evans R.D., The Atomic Nucleus
7. Leo W.R., Techiniques for Nuclear and Particle Physics Experiments
8. Brodie, I. and Muray, J.J., (2009) Physics of Micro/Nanofabrication, Springer, Plenum Press

o. **Recommended Reading**

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1. Kulkarni, S.K.,(2009) *Nanotechnology: Principles and Practices*, New Delhi, Capital Pub. Co.
2. Knoll G.F., Radiation detection and measurement
3. Wiederrecht, G., (2010) Handbook of Nanofabrication, Elsevier B.V.

p. **Magazines and Journals**
1. The Physics Teacher published by the American Physical Society
2. Contemporary Physics published by the Institute of Physics
3. Resonance published by the Indian Academy of Sciences

q. **Websites**
1. Physics Teacher Resources-aip.org

r. **Other Electronic Resources**

4. Youtube physics experiments

**39. Course Organization**

| | | | |
|---|---|---|---|
| **Course Code** | PYL615A | | |
| **Course Title** | Advanced Physics Laboratory | | |
| **Course Leader/s Name** | | As per Time - table | |
| **Course Leader Contact Details** | | **Phone:** | +91-804-906-5555 |
| | | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | | 14 July 2022 | |
| **Next Course Specifications Review Date** | | July 2024 | |

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**Course Specifications:** Internship

| | |
|---|---|
| Course Title | Internship |
| Course Code | PYI616A |
| Course Type | Laboratory Course |
| Department | Physics |
| Faculty | Mathematical and Physical Sciences |

## 21. Course Summary

Aim of this course is to train students to conduct independent study a topic of relevance and deliver a seminar.

The student is expected choose a topic of relevance and conduct independent study. The student is also expected to submit a report and present the same.

## 22. Course Size and Credits:

| | |
|---|---|
| **Number of Credits** | 01 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 0:0:1 |
| **Total Hours of Interaction** | 30 |
| **Number of Weeks in a Semester** | 15 |
| **Department Responsible** | Physics |
| **Total Course Marks** | 50 |
| **Pass Criterion** | As per the Academic Regulations |
| **Attendance Requirement** | As per the Academic Regulations |

## 23. Course Outcomes (COs)

After the successful completion of this course, the student will be able to:

**CO-3.** Write a report on experiences during internship
**CO-4.** Make a presentation to a panel of examiners

## 24. Course Contents

Choose relevant industry/business organization/research organization/university

Undergo internship

Prepare a scientific report and give a presentation on the same topic

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**25. Course Map (CO-PO-PSO Map)**

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | | | | | | | | | 3 | | | | 3 |
| CO-2 | | | | | | | | | 3 | | | | 3 |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

**26. Course Teaching and Learning Methods**

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| Face to Face Lectures | | 00 |
| Demonstrations | | 00 |
| 1.Demonstration using Videos | 00 | |
| 2. Demonstration using Physical Models / Systems | 00 | |
| 3. Demonstration on a Computer | 00 | |
| Numeracy | | 00 |
| 1. Solving Numerical Problems | 00 | |
| Practical Work | | 00 |
| 1. Course Laboratory | 00 | |
| 2. Computer Laboratory | 00 | |
| 3. Engineering Workshop / Course/Workshop / Kitchen | 00 | |
| 4. Clinical Laboratory | 00 | |
| 5. Hospital | 00 | |
| 6. Model Studio | 00 | |
| Others | | 120 |
| 1. Case Study Presentation | 120 | |
| 2. Guest Lecture | 00 | |
| 3. Industry / Field Visit | 00 | |
| 4. Brain Storming Sessions | 00 | |
| 5. Group Discussions | 00 | |
| 6. Discussing Possible Innovations | 00 | |
| Term Tests, Laboratory Examination/Written Examination, Presentations | | 08 |
| **Total Duration in Hours** | | **128** |

**27. Course Assessment and Reassessment**

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M. Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document. Course reassessment policies are presented in the Academic Regulations document.

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## 28. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Literature reading |
| 2. | Understanding | Literature reading |
| 3. | Critical Skills | Literature reading |
| 4. | Analytical Skills | Literature reading |
| 5. | Problem Solving Skills | Drawing conclusions from the literature |
| 6. | Practical Skills | Literature reading, preparation of report |
| 7. | Group Work | |
| 8. | Self-Learning | Literature reading, preparation of report |
| 9. | Written Communication Skills | Preparation of report |
| 10. | Verbal Communication Skills | Presentation of report |
| 11. | Presentation Skills | Presentation of report |
| 12. | Behavioral Skills | Course work |
| 13. | Information Management | Presentation of report |
| 14. | Personal Management | Course work |
| 15. | Leadership Skills | --- |

## 29. Course Resources

c. **Essential Reading**

1. Literature / Discussion with allotted supervisor/s

## 30. Course Organization

| | | |
|---|---|---|
| **Course Code** | PYI616A | |
| **Course Title** | Internship | |
| **Course Leader's Name** | As per Timetable | |
| **Course Leader's Contact Details** | **Phone:** | +91-804-906-5555 |
| | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | 14 July 2022 | |
| **Next Course Specifications Review Date** | July 2024 | |

**Course Specifications:** Seminar 2

| | |
|---|---|
| Course Title | Seminar 2 |
| Course Code | PYS617A |
| Course Type | Core Laboratory Course |
| Department | Physics |
| Faculty | Mathematical and Physical Sciences |

**31. Course Summary**

The aim of this course is to train students to conduct independent study a topic of relevance and deliver a seminar.

The student is expected choose a topic of relevance and conduct independent study. The student is also expected to submit a report and present the same.

**32. Course Size and Credits:**

| | |
|---|---|
| **Number of Credits** | 01 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 0:0:1 |
| **Total Hours of Interaction** | 30 |
| **Number of Weeks in a Semester** | 15 |
| **Department Responsible** | Physics |
| **Total Course Marks** | 50 |
| **Pass Criterion** | As per the Academic Regulations |
| **Attendance Requirement** | As per the Academic Regulations |

**33. Course Outcomes (COs)**

After the successful completion of this course, the student will be able to:

**CO-5.** Conduct a thorough literature review and submit a review article / scientific report
**CO-6.** Make a presentation to a panel of examiners

**34. Course Contents**

Choose the relevant research topic
Study literature and give seminar
Prepare a review article/ scientific report and give a presentation on the same topic

**35. Course Map (CO-PO-PSO Map)**

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| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | | 2 | | | | | | | 3 | | 2 | | 3 |
| CO-2 | | 2 | | | | | | | 3 | | 2 | | 3 |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

## 36. Course Teaching and Learning Methods

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| **Face to Face Lectures** | | |
| **Demonstrations** | | 00 |
| 1.Demonstration using Videos | 00 | |
| 2. Demonstration using Physical Models / Systems | 00 | |
| 3. Demonstration on a Computer | 00 | |
| **Numeracy** | | 00 |
| 1. Solving Numerical Problems | 00 | |
| **Practical Work** | | 00 |
| 1. Course Laboratory | 00 | |
| 2. Computer Laboratory | 00 | |
| 3. Engineering Workshop / Course/Workshop / Kitchen | 00 | |
| 4. Clinical Laboratory | 00 | |
| 5. Hospital | 00 | |
| 6. Model Studio | 00 | |
| **Others** | | 30 |
| 1. Case Study Presentation | 30 | |
| 2. Guest Lecture | 00 | |
| 3. Industry / Field Visit | 00 | |
| 4. Brain Storming Sessions | 00 | |
| 5. Group Discussions | 00 | |
| 6. Discussing Possible Innovations | 00 | |
| Term Tests, Laboratory Examination/Written Examination, Presentations | | 01 |
| **Total Duration in Hours** | | **31** |

## 37. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M. Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document. Course reassessment policies are presented in the Academic Regulations document.

## 38. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching



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and learning methods:

| S. No | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Literature reading |
| 2. | Understanding | Literature reading |
| 3. | Critical Skills | Literature reading |
| 4. | Analytical Skills | Literature reading |
| 5. | Problem Solving Skills | Drawing conclusions from the literature |
| 6. | Practical Skills | Literature reading, preparation of report |
| 7. | Group Work | |
| 8. | Self-Learning | Literature reading, preparation of report |
| 9. | Written Communication Skills | Preparation of report |
| 10. | Verbal Communication Skills | Presentation of report |
| 11. | Presentation Skills | Presentation of report |
| 12. | Behavioral Skills | Course work |
| 13. | Information Management | Presentation of report |
| 14. | Personal Management | Course work |
| 15. | Leadership Skills | --- |

**39. Course Resources**

**d. Essential Reading**

1. Books / Research Articles

**40. Course Organization**

| | | |
|---|---|---|
| **Course Code** | PYS617A | |
| **Course Title** | Seminar 2 | |
| **Course Leader's Name** | As per Timetable | |
| **Course Leader's Contact Details** | **Phone:** | +91-804-906-5555 |
| | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | 14 July 2022 | |
| **Next Course Specifications Review Date** | July 2024 | |

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**Course Specifications:** Semiconductor Physics

| | |
|---|---|
| Course Title | Semiconductor Physics |
| Course Code | PYC632A |
| Course Type | Core Theory Course |
| Department | Physics |
| Faculty | Faculty of Mathematical and Physical Sciences |

## I. Course Summary

In this course the students will learn how the fundamental concepts of quantum mechanics and solid state physics are applied to technologically important semiconductors such as Si, Ge, Ga As etc. This Course introduces the students to electronic band structures, band gaps and the carrier distribution. The electric transport properties and the optical properties of these bulk materials are then explained. The principles of a number of semiconductor devices based on PN junction such as solar cell, photodetectors and different types of diodes are discussed. A discussion on spintronic materials and organic semiconductors will help the students to get an idea on some of the advanced electronic materials.

## 2. Course Size and Credits:

| | |
|---|---|
| **Number of credits** | 04 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 3:1:0 |
| **Total hours of interaction** | 60 |
| **Number of Weeks in a Semester** | 15 |
| **Department responsible** | Physics |
| **Total Course Marks** | 100 |
| **Pass requirement** | As per the Academic Regulations |
| **Attendance requirement** | As per the Academic Regulations |

## 53. Course Objectives (CO)

After the successful completion of this course, the student will be able to:

**CO - 1** Explain the basic concepts and the fundamental knowledge from quantum mechanics and solid state physics to the technologically important and useful semiconductor materials and their properties

**CO - 2** Discuss the transport mechanism and carrier distribution in intrinsic and extrinsic semiconductors and analyze how the conductivity in semiconductors varies with temperature, illumination and doping concentration

**CO - 3** Solve numerical problems on electron - hole concentration in a semiconductor, PN junction and other semiconductor devices

**CO - 4** Describe and analyze the characteristics of PN junction, solar cells, photodetectors and other important semiconductor devices

**CO - 5** Apply the fundamental knowledge from quantum mechanics and solid state physics to design and study the advanced electronic materials.

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## 54. Course Contents

### Quantum theory of solids

Energy band formation—Bloch Theorem and Kronig-Penney model—E-K diagrams--Structures of semiconductors - Electronic energy bands—concept of effective mass—density of states in semiconductors— electron and hole number densities in valence and conduction bands under thermal equilibrium-Intrinsic carrier concentration - The Law of Mass Action—Intrinsic fermi level position—doped and compensated semiconductors—degenerate and non-degenerate semiconductors-charge carrier concentrations in doped and compensated semiconductors—position of fermi level in intrinsic and extrinsic semiconductors—variation of Fermi energy with doping concentration and temperature-Relevance of Fermi energy

An overview of charge carrier transport properties – Drift—diffusion—graded impurity distribution—Einstein's relation

### P-N Junctions

P-N Junction under thermal equilibrium condition-built-in potential barrier-Electric field and space charge width - Depletion region-Non-Uniformly doped junctions- Abrupt junction-Linearly graded junction - Depletion capacitance -Capacitance-voltage characteristics. Varactor-Current-voltage characteristics. Junction breakdown-Tunneling effect-Avalanche multiplication.

### Opto-Electronic Devices

Optical absorption coefficient—Electron-hole pair generation rate-Basic transitions in semiconductors-solar cells-I-V characteristics and efficiency photo conductors-Expression for gain in a photoconductor- LEDs-Internal and external quantum efficiency-LED devices- GaAs as a material for optical devices-Tunnel diode-GUNN diode-IMPATT diode- Thyristor – Basic characteristics, Applications.

### Advanced Electronic materials

Spintronic materials, Dilute magnetic semiconductors, Magnetites, Giant-magneto resistance materials, Organic semiconductors and applications, Molecular switches.

## 55. Course Map (CO-PO-PSO Map)

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 3 | 3 | 1 | | 1 | 2 | 1 | | 1 | | 3 | 1 | 2 |
| CO-2 | 3 | 2 | | 2 | | | 2 | | | | 3 | 2 | 2 |
| CO-3 | 2 | 2 | 1 | | | 2 | | | 1 | | 2 | | 2 |
| CO-4 | 3 | 2 | | | 2 | 2 | | 2 | | | 3 | 2 | 2 |
| CO-5 | 3 | 2 | 1 | 2 | | | 3 | | 2 | | 3 | 2 | 3 |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

## 56. Course Teaching and Learning Methods

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| Face to Face Lectures | | 42 |
| Demonstrations | | 03 |
| 1.Demonstration using Videos | | |
| 2.Demonstration using Physical Models / Systems | 1 | |



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| | | |
|---|---|---|
| 3.Demonstration on a Computer | 2 | |
| **Numeracy** | | 15 |
| 1. Solving Numerical Problems | 15 | |
| **Practical Work** | | 00 |
| 1. Course Laboratory | | |
| 2. Computer Laboratory | | |
| 3. Engineering Workshop / Course Workshop / Kitchen | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | 00 |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry / Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| Term Tests, Written Examination | | 10 |
| Total Duration in Hours | | 70 |

**57. Course Assessment and Reassessment**

The details of the components and subcomponents of course assessment is presented in the Programme Specifications document pertaining to the M.Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

**9 Achieving COs**

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No. | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Classroom lectures |
| 2. | Understanding | Class room lectures, and demonstrations |
| 3. | Critical Skills | Assignment |
| 4. | Analytical Skills | Class room, assignment |
| 5. | Problem Solving Skills | Class room, assignment |
| 6. | Practical Skills | Class room, assignment |
| 7. | Group Work | Classroom |
| 8. | Self-Learning | Assignment |



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| | | |
|---|---|---|
| 9. | Written Communication Skills | Assignment, examination |
| 10. | Verbal Communication Skills | Presentation |
| 11. | Presentation Skills | Presentation |
| 12. | Behavioral Skills | Course |
| 13. | Information Management | Assignment, examination |
| 14. | Personal Management | Assignment, examination |
| 15. | Leadership Skills | Effective management of learning, time management, achieving the learning outcomes |

**11. Course resources**

**jj. Essential Reading**


1. Class Notes
2. Donald, A., Neamen, (2007) Semiconductor Physics and devices, USA: TMH
3. Balkanski M. & Wallis R. F.,( 2000) Semiconductor physics and applications, Oxford University Press, Oxford.
4. Aschcroft N.W. & Mermin N.D., (1976) Solid State Physics, Saunders College Publishing, New York: Harcourt Brace College publishers
5. Sze S. M. (1998) Modern semiconductor device physics, New York:John Wiley & Sons,Inc.
6. Pyshkin & Ballato (2013) Optoelectronics - Advanced Materials and Devices, InTech.


**b. Recommended Reading**


1. Seeger K. (1999) Semiconductor physics, Berlin: Springer.
2. Grahn H. T.( 1999) Introduction to semiconductor physics, World Scientific Singapore.
3. Enderlein R, Horing. N. J. M., (1997) Fundamentals of semiconductor physics and devices, World Scientific, Singapore.
4. Peter Y. Yu, Cardona M., (2005) Fundamentals of semiconductors, Berlin: Springer.
5. Sze S.M. & Ng K. K., (2007) Physics of semiconductor devices
6. Weisbuch C., Vinter, B, (1991) Quantum semiconductor structures, Boston: Academic Press, Inc.


**d. Magazines and Journals**

5. The Physics Teacher published by the American Physical Society
6. American Journal of Physics published by the American Physical Society
7. Contemporary Physics published by the Institute of Physics
8. Resonance published by the Indian Academy of Sciences

**f. Websites**

Physics Teacher Resources-aip.org

**g. Other Electronic Resources**

1. Electronic resources on the subject area are available on MSRUAS library

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2. Youtube physics lectures
3. Youtube physics experiments

## 12. Course Organization

| | | |
|---|---|---|
| **Course Code** | PYC632A | |
| **Course Title** | Semiconductor Physics | |
| **Course Leader/s Name** | As per Time - table | |
| **Course Leader Contact Details** | **Phone:** | +91-804-906-5555 |
| | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | 14 July 2022 | |
| **Next Course Specifications Review Date** | July 2024 | |

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**Course Specification:** Reactor Physics, Shielding and Safety'

| | |
|---|---|
| Course Title | Reactor Physics, Shielding and Safety |
| Course Code | PYC642A |
| Course Type | Core Theory Course |
| Department | Physics |
| Faculty | Faculty of Mathematical and Physical Sciences |

**8. Course Summary**

This course deals with study of reactor physics, shielding and safety. The basics of neutron flux, reaction rates and neutron-nucleus are taught. Then neutron population growth by point kinetics model and the role of delayed neutrons presented. Effective multiplication factor is introduced. Diffusion equation and the elements of reactor calculation methods starting from one group diffusion equation are taught. The equation is solved for simple geometries. Energy dependent multigroup diffusion and concepts of resonance self-shielding is introduced. Neutron spectra in reactors are presented. Radioactive growth and decay in reactor systems and the effect of fission products on the dynamics of the reactor introduced.
Temperature effects on reactivity is discussed.

Basic definitions and quantities in radiation dosimetry is introduced. Radiation shielding calculation methods are explained. Gamma ray attenuation and dose calculations for extended sources are presented and complex geometries discussed.

Overview of Heavy water reactors, light water reactors, gas cooled reactors, liquid metal cooled reactors, Gen-IV reactor concepts, Fusion reactors and Accelerator Driven Systems is given. Reactor materials and radiation damage are discussed. Elements of reactor safety provisions and methods discussed. Methodology of event-tree and fault-tree analysis are described. Radioactive waste management principles and methods discussed. Environmental dispersion models and nuclear decommissioning methods are explained

**9. Course Size and Credits:**

| | |
|---|---|
| **Number of credits** | 04 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 3:1:0 |
| **Total hours of interaction** | 60 |
| **Number of Weeks in a Semester** | 15 |
| **Department responsible** | Physics |
| **Total Course Marks** | 100 |
| **Pass requirement** | As per the Academic Regulations |
| **Attendance requirement** | As per the Academic Regulations |

**10. Course Objectives**

After the successful completion of this course, the student will be able to:

**CO - 1** Explain the basic concepts of neutron reaction cross sections, neutron multiplication, neutron balance in multiplying media, energy spectra of neutrons, radioactivity evolution, dose and shielding, radiation damage of materials, waste management and environmental impact

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**CO - 2** Describe various models for calculation of effective multiplication factor and neutron growth, discuss diffusion equation and solutions for various geometries, radioactivity equilibria equations, methods of calculation for radiation shielding for complex geometries, event tree and fault tree analysis for accidents, Gaussian plume model for environmental dispersion

**CO - 3** Solve problems on various reaction rates in reactor systems, kinetics of neutron multiplication, diffusion equation for sample material zones and materials, estimation of radiation damage and shield requirement for various sources. Compute probabilities of occurrence of accidents for simple scenarios.
Estimate environmental doses due to emission

**CO - 4** Discuss the applications in the areas of thermal and fast fission reactor systems including Gen 4 concepts, fusion systems, and accelerator driven systems.

**CO - 5** Describe various ICRP and AERB principles and regulatory concepts on doses and radioactivity concentrations.

**11. Course Contents**

**Introduction to Physics of nuclear reactors**

Basic concepts: neutron-matter interaction, cross sections, orders of magnitude, qualitative aspects, mean free path. Neutron density, current, flux and reaction rates. neutron spectrum (fast and thermal reactor). Neutron Balance, four-factor formula. Point kinetics – Prompt kinetics, delayed neutron kinetics equations, Analytic solution of the one delayed neutron group with constant reactivity. Diffusion equation – Elementary neutron balance.

**Reactor calculation basics**

One group diffusion theory – Criticality condition of an homogeneous naked pile: material and geometric buckling; core with reflector; Solutions for simple geometry, study of a 2 zone reactor – Isotropic and anisotropic scattering; Center of mass frame and laboratory frame of reference; elastic collision; lethargy; Neutron moderator. Neutron resonant absorption – resonance escape probability for homogeneous geometry. Self-shielding and effective cross section for narrow resonance, Thermalization of neutron – Qualitative aspects, Maxwell spectrum. Thermalization equation, real spectrum.

Multigroup diffusion theory – basic concepts of the multigroup theory

**Radioactive growth and decay**

Radioactive decay law, half-life, mean lifetime, activity, partial decay constants, decay branching ratios, growth of a daughter product, time of maximum activity, ideal equilibrium, transient equilibrium, secular equilibrium, residual activity. Statistics and uncertainty reminder. Induced radioactivity, yield, maximum activity, accumulated activity.

Fission product poisoning of a reactor core – fission product generalities; Xenon effect, Samarium effect. Temperature effect – definition; requirements of negative temperature coefficients. Burnable poisons. Reactivity feedback.

**Radiation dosimetry and radiation shielding:**

Dosimetric quantities and units; Quantities and units used in radiological protection. Biological effects, including deterministic and stochastic effects. Risk estimates and a comparison with other occupational risks. International Commission on Radiological Protection (ICRP): principles and recommendations. External and Internal hazards; control measures and monitoring. Dose calculations. Annual limits on intake. Practical aspects of



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radiological monitoring systems - electronic dosimeters, TL dosimeters, film badges; neutron dosimetry.

Gamma ray and neutron shielding calculations; gamma -ray attenuation and build-up factors. Treatment of complex geometries

**Reactor Systems and Safety Analysis:**

Overview of different types of reactors – Heavy water reactors, light water reactors, gas cooled reactors, liquid metal cooled reactors. Gen-IV reactor concepts. Fusion reactor and Accelerator Driven Systems

Materials and radiation damage, safety factors affecting temperature and performance. Emergency shut-down and core-cooling plant. Auxiliary shutdown and emergency core-cooling plant. Loss-of-coolant accidents. Reactor safety: Methodology of event-tree and fault-tree analysis.

**Environmental impact of nuclear power:**

Sources of activity from the nuclear fuel cycle: discharges from fuel production plants, nuclear power stations and reprocessing plants during operation and decommissioning. Dispersal of radioactive material – Gaussian Plume model. Radiological consequences of the Chernobyl and other reactor accidents; comparison with other accidents.

Sources and characteristics of nuclear wastes, short lived and long-lived waste radionuclide, Management and characterization of radioactive wastes. Nuclear transmutation of long-lived waste, Pretreatment of radioactive wastes, Treatment of Radioactive wastes, Immobilization of radioactive wastes in cement, bitumen and glass, new immobilizing hosts and technologies. Nuclear waste management – Indian scenario.

Stages of decommissioning. Reactor decommissioning- the safe store concept. Decontamination and dismantling techniques.

**12. Course Map (CO-PO-PSO Map)**

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 2 | 2 | 2 | | | | 3 | | | 1 | 2 | | 3 |
| CO-2 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | | | 1 | 2 | 3 | 3 |
| CO-3 | 2 | 2 | 2 | | 2 | 2 | 3 | | | 1 | 2 | 2 | 3 |
| CO-4 | 2 | 2 | | | 2 | 2 | 3 | | | 1 | 2 | 2 | 3 |
| CO-5 | 2 | 2 | | | | 2 | 3 | | | 1 | 2 | | 3 |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

**13. Course Teaching and Learning Methods**

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| **Face to Face Lectures** | | 42 |
| **Demonstrations** | | 03 |
| 4. Demonstration using Videos | 01 | |
| 5. Demonstration using Physical Models / Systems | | |
| 6. Demonstration on a Computer | 02 | |
| **Numeracy** | | 15 |
| 1. Solving Numerical Problems | 15 | |

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| Practical Work | | |
|---|---|---|
| 4. Course Laboratory | | 00 |
| 5. Computer Laboratory | | |
| 6. Engineering Workshop / Course Workshop | | |
| 4. Clinical Laboratory | | |
| 5. Hospital | | |
| 6. Model Studio | | |
| **Others** | | 00 |
| 1. Case Study Presentation | | |
| 2. Guest Lecture | | |
| 3. Industry / Field Visit | | |
| 4. Brain Storming Sessions | | |
| 5. Group Discussions | | |
| 6. Discussing Possible Innovations | | |
| Term Tests, Written Examination | | 10 |
| | Total Duration in Hours | 70 |

**14. Course Assessment and Reassessment**

The details of the components and subcomponents of course assessment is presented in the Programme Specifications document pertaining to the M.Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document.

**10 Achieving COs**

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No. | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Classroom lectures |
| 2. | Understanding | Class room lectures, and demonstrations |
| 3. | Critical Skills | Assignment |
| 4. | Analytical Skills | Class room, assignment |
| 5. | Problem Solving Skills | Class room, assignment |
| 6. | Practical Skills | Class room, assignment |
| 7. | Group Work | Classroom |
| 8. | Self-Learning | Assignment |
| 9. | Written Communication Skills | Assignment, examination |
| 10. | Verbal Communication Skills | Presentation |
| 11. | Presentation Skills | Presentation |
| 12. | Behavioral Skills | Course |
| 13. | Information Management | Assignment, examination |
| 14. | Personal Management | Assignment, examination |
| 15. | Leadership Skills | Effective management of learning, time management, achieving the learning |

**13. Course resources**

**c. Essential Reading**

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6. Class Notes
7. Frank H Attix., (1986) Introduction to Radiological Physics and Radiation Dosimetry, Wiley.
8. James E martin., (2006) Physics for radiation protection – A hand Book, Wiley.
9. Micheal G Stabin., (2007) Radiation protection and dosimetry-An introduction to Health Physics, Springer.
10. Gad Shani., (1991) Radiation dosimetry instrumentation and methods.
11. John C Lee, Norman J, Mc Cormick., ( 2012) Risk and safety analysis of nuclear systems, Wiley.

**d. Recommended Reading**

4. Earl N. Mallory. (2010) Nondestructive Testing: Methods, Analyses and Applications
5. James Saling . (2001)Radioactive waste management –, 2nd edition, Taylor and Francis.
6. Ojovan M.I. & Lee W.E. ( 2005) An introduction to Nuclear waste immobilization – Elsevier Ltd
7. Mason Willrich, Richard K. Lester. (1977) Radioactive Waste Management and Regulation, the Free Press.
8. Abramson, P. B. (1985) Guide Book to light water reactor safety analysis, Hemisphere Public corp.

**c. Magazines and Journals**

Journal of Nuclear Physics

**e. Websites**

2. http://science.energy.gov/np/
3. http://www.eps.org

**e. Other Electronic Resources**

3. www.nptel.ac.in


14. **Course Organization**

| | | | |
|---|---|---|---|
| **Course Code** | PYC642A | | |
| **Course Title** | Reactor Physics, Shielding and Safety' | | |
| **Course Leader/s Name** | | As per Time - table | |
| **Course Leader Contact Details** | | **Phon** | +91-804-906-5555 |
| | | E- | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | | 14 July 2022 | |
| **Next Course Specifications Review Date** | | July 2024 | |

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**Course Specifications:** Internship - 2

| | |
|---|---|
| Course Title | Internship - 2 |
| Course Code | PYI621A |
| Course Type | Laboratory Course |
| Department | Physics |
| Faculty | Mathematical and Physical Sciences |

## 41. Course Summary

Aim of this course is to train students to conduct independent study a topic of relevance and deliver a seminar.

The student is expected choose a topic of relevance and conduct independent study. The student is also expected to submit a report and present the same.

## 42. Course Size and Credits:

| | |
|---|---|
| **Number of Credits** | 03 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 0:0:3 |
| **Total Hours of Interaction** | 90 |
| **Number of Weeks in a Semester** | 15 |
| **Department Responsible** | Physics |
| **Total Course Marks** | 100 |
| **Pass Criterion** | As per the Academic Regulations |
| **Attendance Requirement** | As per the Academic Regulations |

## 43. Course Outcomes (COs)

After the successful completion of this course, the student will be able to:

**CO-7.** Write a report on experiences during internship
**CO-8.** Make a presentation to a panel of examiners

## 44. Course Contents

Choose relevant industry/business organization/research organization/university

Undergo internship

Prepare a scientific report and give a presentation on the same topic

## 45. Course Map (CO-PO-PSO Map)

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| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | | | | | | | | | 3 | | | | 3 |
| CO-2 | | | | | | | | | 3 | | | | 3 |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

## 46. Course Teaching and Learning Methods

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| **Face to Face Lectures** | | 00 |
| **Demonstrations** | | 00 |
| 1.Demonstration using Videos | 00 | |
| 2. Demonstration using Physical Models / Systems | 00 | |
| 3. Demonstration on a Computer | 00 | |
| **Numeracy** | | 00 |
| 1. Solving Numerical Problems | 00 | |
| **Practical Work** | | 00 |
| 1. Course Laboratory | 00 | |
| 2. Computer Laboratory | 00 | |
| 3. Engineering Workshop / Course/Workshop / Kitchen | 00 | |
| 4. Clinical Laboratory | 00 | |
| 5. Hospital | 00 | |
| 6. Model Studio | 00 | |
| **Others** | | 90 |
| 1. Case Study Presentation | 90 | |
| 2. Guest Lecture | 00 | |
| 3. Industry / Field Visit | 00 | |
| 4. Brain Storming Sessions | 00 | |
| 5. Group Discussions | 00 | |
| 6. Discussing Possible Innovations | 00 | |
| Term Tests, Laboratory Examination/Written Examination, Presentations | | 08 |
| **Total Duration in Hours** | | **128** |

## 47. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M. Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document. Course reassessment policies are presented in the Academic Regulations document.

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## 48. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Literature reading |
| 2. | Understanding | Literature reading |
| 3. | Critical Skills | Literature reading |
| 4. | Analytical Skills | Literature reading |
| 5. | Problem Solving Skills | Drawing conclusions from the literature |
| 6. | Practical Skills | Literature reading, preparation of report |
| 7. | Group Work | |
| 8. | Self-Learning | Literature reading, preparation of report |
| 9. | Written Communication Skills | Preparation of report |
| 10. | Verbal Communication Skills | Presentation of report |
| 11. | Presentation Skills | Presentation of report |
| 12. | Behavioral Skills | Course work |
| 13. | Information Management | Presentation of report |
| 14. | Personal Management | Course work |
| 15. | Leadership Skills | --- |

## 49. Course Resources

**e. Essential Reading**

1. Literature / Discussion with allotted supervisor/s

## 50. Course Organization

| Course Code | PYI621A | |
|---|---|---|
| Course Title | Internship 2 | |
| Course Leader's Name | As per Timetable | |
| Course Leader's Contact Details | Phone: | +91-804-906-5555 |
| | E-mail: | hod.pi.mp@msruas.ac.in |
| Course Specifications Approval Date | 14 July 2022 | |
| Next Course Specifications Review Date | July 2024 | |

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**Course Specifications:** Dissertation

| | |
|---|---|
| Course Title | Dissertation |
| Course Code | PYP622A |
| Course Type | Laboratory Course |
| Department | Physics |
| Faculty | Mathematical and Physical Sciences |

## 51.Course Summary

The aim of this module is to train a student to carry out research work. The research work will be carried out at MSRUAS or in any other laboratory of student's choice under the supervision of a senior researcher. The duration of the research work is for six months. The student is expected to submit a dissertation and make a presentation to the examiners in the faculty.

## 52. Course Size and Credits:

| | |
|---|---|
| **Number of Credits** | 12 |
| **Credit Structure (Lecture: Tutorial: Practical)** | 0:0:12 |
| **Total Hours of Interaction** | 360 |
| **Number of Weeks in a Semester** | 15 |
| **Department Responsible** | Physics |
| **Total Course Marks** | 300 |
| **Pass Criterion** | As per the Academic Regulations |
| **Attendance Requirement** | As per the Academic Regulations |

## 53. Course Outcomes (COs)

After the successful completion of this course, the student will be able to:

**CO-9.** Recognize the need for developing a new or improving an existing scientific problem through an organized survey of literature

**CO-2.** Define scientific problem

**CO-3.** Design and perform the experiments

**CO-4.** Analyse the results obtained

**CO-5.** Write a technical Report and give presentation

## 54. Course Contents

Selection of topic for research

Critical review on the chosen topic

Performance of experiments

Collection of relevant data

Interpretation of data

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Preparation of dissertation report and presentation of the same

## 55. Course Map (CO-PO-PSO Map)

| | Programme Outcomes (POs) | | | | | | | | | | Programme Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PSO-1 | PSO-2 | PSO-3 |
| CO-1 | 3 | | 3 | | 3 | | | | | | 3 | 3 | |
| CO-2 | | | 3 | | 3 | | | 3 | | | 3 | 3 | 3 |
| CO-3 | | | 3 | 3 | 3 | | | 3 | | | 3 | 3 | 3 |
| CO-4 | | | | | 3 | | | 3 | | | | 3 | 3 |
| CO-5 | | | | | | 3 | | | 3 | 2 | | | 3 |
| 3: Very Strong Contribution, 2: Strong Contribution, 1: Moderate Contribution | | | | | | | | | | | | | |

## 56. Course Teaching and Learning Methods

| Teaching and Learning Methods | Duration in hours | Total Duration in Hours |
|---|---|---|
| Face to Face Lectures | | 00 |
| Demonstrations | | 00 |
| 1.Demonstration using Videos | 00 | |
| 2. Demonstration using Physical Models / Systems | 00 | |
| 3. Demonstration on a Computer | 00 | |
| Numeracy | | 00 |
| 1. Solving Numerical Problems | 00 | |
| Practical Work | | 00 |
| 1. Course Laboratory | 00 | |
| 2. Computer Laboratory | 00 | |
| 3. Engineering Workshop / Course/Workshop / Kitchen | 00 | |
| 4. Clinical Laboratory | 00 | |
| 5. Hospital | 00 | |
| 6. Model Studio | 00 | |
| Others | | 360 |
| 1. Case Study Presentation / Solving Research Problem | 360 | |
| 2. Guest Lecture | 00 | |
| 3. Industry / Field Visit | 00 | |
| 4. Brain Storming Sessions | 00 | |
| 5. Group Discussions | 00 | |
| 6. Discussing Possible Innovations | 00 | |
| Term Tests, Laboratory Examination/Written Examination, Presentations | | 10 |
| Total Duration in Hours | | 370 |

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## 57. Course Assessment and Reassessment

The details of the components and subcomponents of course assessment are presented in the Programme Specifications document pertaining to the M. Sc. Programmes. The procedure to determine the final course marks is also presented in the Programme Specifications document.

The evaluation questions are set to measure the attainment of the COs. In either component (CE or SEE) or subcomponent of CE (SC1,), COs are assessed as illustrated in the following Table.

| Focus of COs on each Component or Subcomponent of Evaluation | | |
|---|---|---|
| | Component 1: CE (33 % Weightage) | Component 2: (67 % Weightage) |
| Subcomponent ▶ | SC1 | |
| Subcomponent Type ▶ | Pre-project (40 marks) and Mid Term (60 Marks) Presentation | Final Project Presentation (50 Marks), Report (100 Marks) Journal Article (50 Marks) |
| Maximum Marks ▶ | 100 | 200 |
| CO-1 | X | |
| CO-2 | X | X |
| CO-3 | X | X |
| CO-4 | | X |
| CO-5 | | X |
| The details of SC1 are presented in the Programme Specifications Document. | | |

The Course Leader assigned to the course, in consultation with the Head of the Department, shall provide the focus of COs in each component of assessment in the above template at the beginning of the semester.

Course reassessment policies are presented in the Academic Regulations document.

## 58. Achieving COs

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

| S. No | Curriculum and Capabilities Skills | How imparted during the course |
|---|---|---|
| 1. | Knowledge | Literature reading |
| 2. | Understanding | Literature reading |
| 3. | Critical Skills | Literature reading |
| 4. | Analytical Skills | Literature reading |

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| | | |
|---|---|---|
| 5. | Problem Solving Skills | Drawing conclusions from the literature |
| 6. | Practical Skills | Literature reading, preparation of report |
| 7. | Group Work | |
| 8. | Self-Learning | Literature reading, preparation of report |
| 9. | Written Communication Skills | Preparation of report |
| 10. | Verbal Communication Skills | Presentation of report |
| 11. | Presentation Skills | Presentation of report |
| 12. | Behavioral Skills | Course work |
| 13. | Information Management | Presentation of report |
| 14. | Personal Management | Course work |
| 15. | Leadership Skills | --- |

**59. Course Resources**

**f. Essential Reading**

1. Research Articles / Dissertation Reports / Books

2. Lecture Sessions on individual project, Thesis Preparation delivered by the concerned Head of Department.

**60. Course Organization**

| | | |
|---|---|---|
| **Course Code** | PYP622A | |
| **Course Title** | Dissertation | |
| **Course Leader's Name** | As per Timetable | |
| **Course Leader's Contact Details** | **Phone:** | +91-804-906-5555 |
| | **E-mail:** | hod.pi.mp@msruas.ac.in |
| **Course Specifications Approval Date** | 14 July 2022 | |
| **Next Course Specifications Review Date** | July 2024 | |

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