Savitribai Phule Pune University

(FormerlyUniversityofPune)

Third Year B.Sc. Program in Physics

(Faculty of Science & Technology)

T.Y.B.Sc. (Physics)

To be implemented from Academic Year 2026-2027

Table of Contents

Abbreviations Used

- PO : Programme Outcomes
- PS : Programme Structure
- TLP : Teaching-Learning Process
- AM : Assessment Method
- DSC : Discipline Specific Core
- DSE : Discipline Specific Elective
- OE : Generic Electives
- OP : Open Electives
- VSC : Vocational Skill Courses
- SEC : Skill Enhancement Courses
- VSC* : Vocational Skill Courses(Can be given as advanced practical course related to major)
- AEC : Ability Enhancement Courses
- IKS : Indian Knowledge System

- VEC : Value Education Courses
- OJT : On Job Training (Internship/ Apprenticeship)
- FP : Field projects
- CEP : Community engagement program
- CC : Co-curricular Courses
- RM : Research Methodology
- RP : Research Project

1) Introduction to Undergraduate Degree Course in Physics:

As per the recommendations of UGC-F-2022, the undergraduate (UG) degree course in Physics is a 6-semester course spread over 3-academic years **OR** 8-semester course spread over 4-academic years. The Teaching Learning Process (TLP) is students' centric. It involves both theory and practical components. It offers a flexibility of programme structure while ensuring that the student gets a strong foundation in the subject and gains in-depth knowledge. Besides the DSCs (Major Core), a student has options courses from the syllabus comprising of DSEs (Electives), Minor, OE/GEs, SECs, AECs, RPs, RMs, OJT, FP, CEP, IKSs, VECs, CCs and VSCs. Hence, this will be bring out the interdisciplinary as well as multidisciplinary approach and adherence to innovative ways within the curriculum framework. It also allow a students' maximum flexibility in pursuing his/her studies at the undergraduate (UG) level to the extent of having the liberty to eventually design the degree with multiple exit options. Students have these exits options depending upon the needs and aspirations of the student in terms of his/her goals of life, without compromising on the teaching learning, both in qualitative and quantitative terms. This will suit the present day needs of students in terms of securing their paths towards higher studies or employment.

2) Programme Duration and Exit Options:

The minimum credit to be earned by a student per semester is 18-credits and the maximum is 26 credits. However, students are advised to earn 22-credits per semester. This provision is meant to provide students the comfort of the flexibility of semester-wise academic load and to learn at his/her own pace. However, the mandatory number of credits which have to be secured for the purpose of award of Undergraduate Certificate/Undergraduate Diploma/Appropriate Bachelor's Degree in Physics are listed in Table-1.

Table-1: List of award of Undergraduate Certificate/ Undergraduate Diploma/Appropriate Bachelor's Degree in Physics

S. No.	Type of Award	Stage of Exit	Mandatory Credits to be Secured for the Award
1	Undergraduate Certificate in Physics	After successful completion of Semester II	**44** and an additional 4 credits core NSQF Course/Internship
2	Undergraduate Diploma in Physics	After successful completion of Semester IV	**88** and an additional 4 credits core NSQF Course/Internship
3	Bachelor of Science Physics	After successful completion of Semester VI	**132**
4	Bachelor of Science Physics (Honours)	After successful completion of Semester VIII	**176**
5	Bachelor of Science Physics (Honours with Research)	After successful completion of Semester VIII with minimum 28 GE credits in Discipline-2 (Minor)	**176**

a) Major Discipline (Physics) :A student pursuing four-year undergraduate programme in Physics (Core course) shall be awarded B.Sc. Honours degree with Major in Physics on completion of VIII Semester, if he/she secures in Physics at least 50% of the total credits i.e., at least 88 credits in Physics out of the total of 176 credits. He/she shall study 20 DSCs and at least 2 DSEs of Physics in eight semesters.

b) Minor Discipline (Discipline-2):A student of B.Sc. (Hons.) Physics may be awarded Minor in a discipline, other than Physics, on completion of VIII Semester, if he/she earns minimum 28 credits from seven GE courses of that discipline

3) Programme Objectives :

The undergraduate (UG) degree course in Physics aims to provide:

a) Knowledge and skills to undertake higher studies/research in physics and related interdisciplinary areas thereby enabling students' employment/entrepreneurship.
b) Critical and analytical thinking, scientific reasoning, problem-solving skills, communication skills and teamwork.
c) Competence and skill in solving both theoretical and applied physics problems.
d) In-depth knowledge in physics through understanding of key physical concepts, principles, theories and their manifestations.
e) Exposure to the latest advances in physics, allied disciplines and research.
f) A conducive learning environment to ensure cognitive development of students.
g) Sufficient subject matter competence and enable students to prepare for various competitive examinations such as UGC-CSIR NET/JRF, GATE, GRE, IIT-JAM, and Civil Services Examinations.
h) Moral and ethical awareness, leadership qualities, innovation and life-long learning.
i) Multicultural competence and multilinguism.

4) Program Outcomes :

The learning outcomes of the undergraduate degree course in physics are as follows:

a) Role of Physics:

The students will develop awareness and appreciation for the significant role played by physics in current societal and global issues. They will be able to address and contribute to such issues through the skills and knowledge acquired during the programme. They will be able identify/mobilize appropriate resources required for a project, and managing a project through to completion, while observing responsible and ethical scientific conduct, safety and laboratory hygiene regulations and practices.

b) Research skills:

The course provides an opportunity to students to hone their research and innovation skills through internship/apprenticeship/project/community-outreach/dissertation/Entrepreneurship/Academic-Project. It will enable the students to demonstrate mature skills in literature survey, information management skills, and data analysis and research ethics.

c) Hands-on/ Laboratory Skills:

Comprehensive hands-on/ laboratory exercises will impart analytical, computational and instrumentation skills. The students will be able to demonstrate mature skills for the collation, evaluation, analysis and presentation of information, ideas, concepts as well as quantitative and/or qualitative data.

d) In-depth disciplinary knowledge:

The student will acquire comprehensive knowledge and understanding of the fundamental concepts, theoretical principles and processes in the main and allied branches of physics. The core papers will provide in-depth understanding of the subject. A wide choice of elective courses offered to the student will provide specialized understanding rooted in the core and interdisciplinary areas.

e) Communication and IT Skills:

Various DSCs, DSEs, SECs, GEs and AECs have been designed to enhance student's ability to write methodical, logical and precise reports. The courses will, in addition, guide the student to communicate effectively through oral/poster presentations, writing laboratory/ project reports and dissertations. Several IT based papers in DSCs, DSEs, SECs and AECs will enable students to develop expertise in general and subject specific computational skills.

f) Critical and Lateral Thinking:

The programme will develop the ability to apply the underlying concepts and principles of physics and allied fields beyond the classrooms to real life applications, innovation and creativity. A student will be able to distinguish between relevant and irrelevant facts and information, discriminate between objective and biased information, apply logic to arrive at definitive conclusions, find out if conclusions are based upon sufficient evidence, derive correct quantitative results, make rational evaluations, and arrive at qualitative judgments according to established rules.

5) Programme Structure :

The detailed Credit framework of undergraduate degree programme in Physics is provided in Table 2.

Table-2: Credit framework of undergraduate degree programme in Physics.

Level /Difficulty	Sem	Subject-1				Subject-2	Subject-3	GE/ OE	SEC	IKS	AEC	VEC	CC	Total
4.5/100	I	2(T)+2(P)				2(T)+2(P)	2(T)+2(P)	2(T)	2(T/P)	2(T) Generic	2(T)	2	-	22
	II	2(T)+2(P)				2(T)+2(P)	2(T)+2(P)	2(P)	2(T/P)	-	2(T)	2	2	22
Exit Option: Award of UG Certificate in Major with 44 credits **and** an additional 4 credits core NSQF Course/Internship **OR** Continue with Major and Minor. **Continue Option:** Student will select one subject among the (Subject-1, Subject-2, and Subject-3) as major and another as minor **and** third subject will be dropped.														
Level /Difficulty	**Sem**	**Credits related to major**				**Minor**		**GE/ OE**	**SEC**	**IKS**	**AEC**	**VEC**	**CC**	**Total**
		Discipline Specific Core (DSC) **Major Core**	Discipline Specific Elective (DSE) **Major Elective**	**VSC**	**FP/ OJT /CEP**									
5.0/200	III	4(T)+2(P)	-	2(T/P)	2 (FP)	2(T)+2(P)	-	2(T)	-	2(T) Major Subject Specific	2(T)	-	2	22
	IV	4(T)+2(P)	-	2(T/P)	2(CEP)	2(T)+2(P)	-	2(P)	2(T/P)	-	2(T)	-	2	22
Exit Option: Award of UG Diploma in Major and Minor with 88 credits **and** an additional 4 credits core NSQF Course/Internship **OR** Continue with Major and Minor.														
5.5/300	V	8(T)+4(P)	2(T)+2(P)	2(T/P)	2 (FP/ CEP)	2(T)	-	-	-	-	-	-	-	22
	VI	8(T)+4(P)	2(T)+2(P)	2(T/P)	4(OJT)	-	-	-	-	-	-	-	-	22
Total 3 Years		44	8	8	10	18	8	8	6	4	8	4	6	132
Exit Option: Award of UG degree in Major with 132 credits **OR** Continue with Major and Minor.														
6.0/400	VII	6(T)+4(P)	2(T)+2(P)	-	4(RP)	4(T)(RM)	-	-	-	-	-	-	-	22
	VIII	6(T)+4(P)	2(T)+2(P)	-	8(RP)	-	-	-	-	-	-	-	-	22
Total 4 Years		64	16	8	22	22	8	8	6	4	8	4	6	176
Exit Option: Award of UG Honours with Research Degree in Major and Minor with 176 credits. **-OR-**														
6.0/400	VII	10(T)+4(P)	2(T)+2(P)	-	-	4(T)(RM)	-	-	-	-	-	-	-	22
	VIII	10(T)+4(P)	2(T)+2(P)	-	4(OJT)	-	-	-	-	-	-	-	-	22
Total 4 Years		72	16	8	14	22	8	8	6	4	8	4	6	176
Exit Option: Award of UG Honours Degree in Major and Minor with 176 credits.														

6) Teaching-Learning Process :

a) The undergraduate programme in Physics is designed to provide students with a sound theoretical background, practical training in all aspects of physics and research.
b) It will help them develop an appreciation of the importance of physics in different contexts.
c) The programme includes foundational as well as in-depth courses that span the traditional sub disciplines of physics.
d) Along with the DSCs there are DSEs, GEs, SECs, AECs and VACs which address the need of the hour.
e) Physics courses will be delivered through the conventional chalk and talk method, laboratory work, projects, case studies, field work, seminars, hands-on training/workshops in a challenging, engaging, and inclusive manner that accommodates a variety of learning styles and ICT enabled teaching-learning tools (PowerPoint presentations, audio visual resources, e-resources, models, software, simulations, virtual labs, etc.).
f) Students will be encouraged to carry out short term projects and participate in industrial and institutional visits and outreach programmes.
g) Students will be introduced to scientific reasoning and discovery, innovative problem-solving methodologies, online quizzes, surveys, critical analysis etc. to develop convergent and divergent thinking abilities.
h) The laboratory training complements the theoretical principles learned in the classroom and includes hands-on experience with modern instruments, computational data analysis, modelling, error estimation and laboratory safety procedures.
i) Different pedagogies such as experiential learning, participative learning, project-based learning, inquiry-based learning and ICT pedagogy integration instruction (blended and flipped learning) will be adopted wherever possible.
j) Students will be encouraged to work in groups to develop their interpersonal skills like communication and team work.
k) Students' diligent and active participation/ engagement in industrial visits/ internships/ academic projects/ dissertations will lay a strong foundation for a successful career in academics, industry, research, entrepreneurship and community outreach.

7) Assessment Methods :

The primary objective of assessment will be to assess the learning outcomes of the course in tune with the broad outcomes of strengthening core theoretical knowledge base, practical laboratory skills, and research. Assessment will be based on continuous evaluation (MCQs, Short Questions (SQ), Class Test (CT), Seminar, Presentation (PPT), Group Discussion (GD), Quiz, Assignment, Tutorials, etc.) and end of semester examination of Savitribai Phule Pune University, Pune.

(i) Internal Assessment or Continuous Evaluation:

During a semester, students' mastery of the various learning outcomes as described in the syllabus will be assessed through MCQs, Short Questions (SQ), Class Test (CT), Seminar, Presentation (PPT), Group Discussion (GD), Quiz, Assignment, Tutorials, etc. Each theory paper and practical paper will

have 20marks for internal assessment. The critical analysis of internal assessment or continuous evaluation outcomes will provide opportunities to improve the teaching-learning process by focusing on the areas that need conceptual strengthening, laboratory exposure or design of new experiments, and research.

(ii) End of Semester University Examinations:

The summative end-semester university examinations will be conducted for both theory and practical courses. Besides internal assessment, each theory paper and each practical paper will be of 50 marks for end of semester examination of the university.

8) Scheme of Examination :

The total marks for a 2-credits course is 50.

- Theory Paper of 02 Credits:
    - Internal Exam (20 M) + University Theory Exam (30 M) = Total 50 M
    - Duration: For Internal exam = 45 Min. and for University Exam = 02 hours.
- Practical Paper of 2 Credits:
    - Internal Exam (20 M) + University Practical Exam (30 M) = Total 50 M
    - Duration: For Internal exam = 45 Min. and for University Exam = More than 04 hours.

Internal exam will be conducted by particular college/institutes at the end of each semester.

External exam will be conducted by Savitribai Phule Pune University, Pune at the end of each semester.

Note:

a) Each semester comprises of 15 weeks.
(12 weeks Actual Teaching + 3 weeks for Continuous Internal Evaluation)

b) One Credit of the Theory is equal to15 clock hours (Teaching 1 hour per week for each credit).
(12 hours Actual Teaching + 3 hours Continuous Internal Evaluation – Assignments, Tutorials, Practice, Problem solving sessions, Group discussion, Seminars and Unit Tests.)

c) One Credit of Practical = 30 clock hours(2 Contact hours per credit per week)
(24 hours' Actual Table work + 6 hours for journal completion, and Continuous Internal Evaluation of each practical)

d) Practical for each course comprises of 02 Credits = 60 clock hours.
    - Minimum 12 laboratory/ Field sessions of 04 clock hours must be conducted in one (1) semester.
    - In case of short practical, two practical should be conducted in one session.
    - Each practical of 04 clock hours in the laboratory should consist of table performance for concerned practical, careful observations, calculation, writing results and conclusion, and submission of practical in written form.
    - Pre-laboratory reading and post laboratory assignments should be given on each practical as a part of continuous internal evaluation.

Pattern for Internal Theory Assessment: (20 Marks)

Que-1: Choose correct option (MCQs) (5-MCQs with Multiple Options) – 5 marks

Que-2: True or False (MCQs) (5-MCQs with Multiple Options) – 5 marks

Que-3: Answer the following questions (Short answer questions) (any 5 out of 7) – 5 marks

Que-4: Answer the following questions (Short answer Definition/Problems/Diagram)(any 5 out of 7)–5marks

Pattern for External Theory Assessment: (30 Marks)

Que-1: Answer the following questions (Short answer/Definition/Problems/Diagram, etc.) (any 5 out of 7)–**5 marks**

Que-2: A) Answer the following questions (Long answer questions) – **5 marks**

i) ----------

ii) ----------

B) Answer the following questions (Long answer questions/Problems) – **3 marks**

i) ----------

ii) ----------

Que-3: A) Answer the following questions (Long answer questions) – **5 marks**

i) ----------

ii) ----------

B) Answer the following questions (Long answer questions/Problems) – **3 marks**

i) ----------

ii) ----------

Que-4: Write a short note on following. (any 3 out of 5) –**9 marks**

a) ----------

b) ----------

c) ----------

d) ----------

e) ----------

X*****rΩb*****X

List of Courses

Note: Every subject has 2 credits.

9) List of Discipline Specific Core (DSC) Courses (Major Core)

Major Core (Semester-I) (4 Credits) (2T+2P)

Semester I

PHY-101-T : Fundamental of Physics-I
PHY 102-P : General Physics Lab-I

Major Core (Semester-II) (4 Credits) (2T+2P)

Semester II

PHY-151-T : Fundamental of Physics-II
PHY-152-P : General Physics Lab-II

Major Core (Semester-III) (6 Credits) (4T+2P)

Semester III

PHY 201 MJ : Mathematical Physics-I
PHY 202(A) MJ : Electronics
PHY 202(B) MJ : Instrumentation
PHY 203 MJP : General Physics Lab-III

Major Core (Semester-IV) (6 Credits) (4T+2P)

Semester IV

PHY 251 MJ : Oscillation, Waves and Sound
PHY 252 MJ : Optics
PHY 253 MJP : General Physics Lab-IV

Major Core (Semester-V) (12 Credits) (8T+4P)

Semester V

PHY 301 MJ : Mathematical Physics-II
PHY 302 MJ : Solid State Physics-I
PHY 303 MJ : Electrodynamics-I
PHY 304 MJ : Classical Mechanics
PHY 305 MJP : General Physics Lab-V
PHY 306 MJP : General Physics Lab-VI

Major Core (Semester-VI) (12 Credits) (8T+4P)

Semester VI

PHY 351 MJ : Atomic and Molecular Physics-I
PHY 352 MJ : Quantum Mechanics-I
PHY 353 MJ : Statistical Mechanics-I
PHY 354 MJ : Nuclear Physics-I
PHY 355 MJP : General Physics Lab-VII
PHY 356 MJP : Physics Lab-VIII (Project-I)

Major Core (Semester-VII) (10 Credits) (6T+4P)

Semester VII

PHY 401 MJ : Atomic and Molecular Physics-II
PHY 402 MJ : Solid State Physics-II
PHY 403 MJ : Electrodynamics-II
PHY 404 MJP : General Physics Lab-IX
PHY 405 MJP: General Physics Lab-X

Major Core (Semester-VIII) (10 Credits)(6T+4P)

Semester VIII

PHY 451 MJ : Quantum Mechanics-II
PHY 452 MJ : Statistical Mechanics-II
PHY 453 MJ : Nuclear Physics-II
PHY 454 MJP : General Physics Lab-XI
PHY 455 MJP : Physics Lab-XII (Project-II)

10) List of Discipline Specific Electives (DSE) Courses (Major Electives)

Semester V :4 Credits. (2T+2P)

PHY 310(A) MJ : Thin films Technology
PHY 310(B) MJ : Functional Nanomaterials
PHY 310(C) MJ : Advanced Electronics (only for Instrumentation subject students)
PHY 311 MJP : Special Physics Lab-I

Semester VI :4 Credits. (2T+2P)

PHY 360(A) MJ : Lasers Technology
PHY 360(B) MJ : Medical Electronics
PHY 361 MJP : Special Physics Lab-II

Semester VII :4 Credits. (2T+2T/P)

PHY 410(A) MJ : Radiation Physics
PHY 410(B) MJ : Remote Sensing
PHY 411 MJP : Special Physics Lab-III

Semester VIII :4 Credits. (2T+2T/P)

PHY 460(A) MJ : Energy Studies
PHY 460(B) MJ : Astronomy and Astrophysics
PHY 461 MJP : Special Physics Lab-IV

11) List of Vocational Skill Courses (VSC):(Each semester: 2 Credits)(P)

Semester-III :

PHY 221 VSC P : Introduction to Computational Physics-I

Semester-IV :

PHY 271 VSC P : Introduction to Computational Physics-II

Semester-V :

PHY 321 VSC P : Solar PV System: Design, and Maintenance

Semester-VI :

PHY 371 VSC P : Modern Electric Vehicle Technology

12) List of Indian Knowledge System (IKS) Courses :(Each semester: 2 Credits)(T)

Semester-I :

As per university circular

Semester-III :

PHY 201 IKS : India's Contribution to Physics

13) List of Minor (MN) Courses :

Semester-III :(4 Credits)(2T+2P)

PHY 241 MN : Applied Physics-I

PHY 242 MNP : Applied Physics Lab-I

Semester-IV :(4 Credits)(2T+2P)

PHY 291 MN : Applied Physics-II

PHY 292 MNP : Applied Physics Lab-II

Semester-V : (2 Credits)(T)

PHY 341 MN : Modern Physics: Concept and Applications

Semester-VII :(4 Credits)(T)

PHY 441 MN : Research Methodology

14) List of Generic Elective (GE)/Open Elective (OE) Courses :

As per University Circular (see basket)

Semester-I : Select any **one** subject for**2-credits (T)**

OE-101-PHY : Physics of Daily Life

OE-102-PHY : Biological Physics

Semester-II : Select any **one** subject for**2-credits (P)**

OE-151-PHY : LED Light - Repairing and Maintenance

OE-152-PHY : Maintenance and Repairing of Physics Lab equipment

Semester-III :2-credits (T)

OE-221-PHY : Eco-friendly Energy for Modern Living

Semester-IV : 2-credits (P)

OE-271-PHY: Li-Battery -Repairing and Maintenance

15) List of Skill Enhancement Courses (SECs) :

Note : **Each semester** for **2(P)**-credits

Semester-I : Select any **one (P)**

SEC-101-PHY : Experimental Skills in Physics

SEC-102-PHY : Physics of Water Filtration Systems

SEC-103-PHY : Renewable Energy and Energy Harvesting

SEC-104-PHY : Programming for Physical Applications (C++ / Python)

Semester-II : Select any **one (P)**

SEC-151-PHY : Numerical Techniques in Physics

SEC-152-PHY : Introduction to Laser and Fibre Optics

SEC-153-PHY : Radiation Safety

SEC-154-PHY : Basic Lab Electric devices and Circuits

Semester-IV: Select any **one (P)**

SEC-251-PHY : Basic Instrumentation Skills

SEC-252-PHY : Sensors and Detection Technology

SEC-253-PHY : Introduction to Physics of Devices

SEC-254-PHY : Technical Design and Drawing of Electronic Circuit

16) List of Value Education Courses (VEC): 2-Credits (T)

Semester-I

As per University Circular (see basket)

Semester-II

As per University Circular (see basket)

17) List of Ability Enhance Courses (AEC): 2-Credits (T)

Semester-I: Select any **one**

AEC-101-ENG : English

Semester-II: Select any **one**

AEC-151-ENG : English

Semester-III: Select any **one**

As per University Circular

AEC-231-HIN : Hindi

AEC-232-MAR : Marathi

Semester-IV: Select any **one**

As per University Circular

AEC-281-HIN : Hindi

AEC-282-MAR : Marathi

18) List of Co-Curricular Courses (CC): 2-Credits

Semester-II: Select any **one**

As per University Circular (see basket)

Semester-III: Select any **one**

As per University Circular (see basket)

Semester-IV: Select any **one**

As per University Circular (see basket)

X*****rΩb*****X

Syllabus of Courses

19) Syllabus of Discipline Specific Core (DSC) Courses (Major Core)

Major Core (Semester V) (12 Credits) (8T+4P)

Note: Every subject has 2 credits

Semester-V

T.Y.B.Sc. (Physics) (Sem-V)

PHY-301-MJ : Mathematical Physics-II

Lectures: 30 hrs **(Credits-02)**

A) Course Objectives: This course aims to introduce

1) To study the basic concepts regarding Mathematical tools to analyse and solve problems in Physics.
2) To impart knowledge about Curvilinear Co-ordinates, theory of relativity, partial differential equations, special functions and Fourier series.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

1) Understand Curvilinear Co-ordinates.
2) Identify applications of partial differential equations and to understand various physical quantities.
3) To understand the concept of special theory of relativity and their significance
4) Perform the calculations in special functions
5) Understand Basic concepts of Fourier Series, Fourier coefficients & its use to solve basic problems.
6) Apply the knowledge of these mathematical techniques applicable to theoretical and practical physics.

C) Instructional design:

1) Lecture method **2)** Tutorial method**3)** Seminars 4) Use of Multimedia
5) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents : Theory

Module-1	Co-ordinate Systems and Partial Differential Equations	Lectures = 12H
	1.1 Review of Cartesian, spherical and cylindrical co-ordinates 1.2 Transformation equation 1.3 General Curvilinear co-ordinate system: Co-ordinate surface, co-ordinate lines, length, surfaces. 1.4 Expressions for gradient, divergence, Laplacian, and curl.	**Lectures = 9**

	1.5 General methods for solving second order PDE 1.6 Method of separation of variables in Cartesian, Spherical polar and cylindrical co-ordinate system (2D Laplace's equation, 1D Wave equation) 1.7 Singular points ($x = x_0$, $x = \infty$) 1.8 Solution of differential equation-Statement of Fuch's theorem, Frobenius method of series solution (Legendre's Equation). **Problem Solving**	**Lectures = 3H**
Module-2	**Special Theory of Relativity**	**Lectures = 8H**
	2.1 Introduction 2.2 Newtonian relativity 2.3 Galilean transformation equation 2.4 Michelson-Morley experiment 2.5 Postulates of special theory of relativity 2.6 Lorentz transformations 2.7 Kinematic effects of Lorentz transformation, Length contraction, Proper time **Problem Solving**	**Lectures = 6H** **Lectures = 2H**
Module-3	**Special Functions and Fourier Series**	**Lectures = 10H**
	Part A: Special Functions 3.1 Introduction 3.2 generating function for Legendre Polynomials: Pn(x), Properties of Legendre Polynomials 3.3 Generating function for Hermite Polynomials: Hn(x), Properties of Hermite Polynomials 3.4 Bessel function of first kind: Jn (x), Properties of Bessel function of first kind **Problem Solving** **Part B: Fourier Series** 3.6 Introduction to Fourier Series 3.7 Dirichlet's Conditions for a Fourier Series 3.8Determination of Fourier coefficients $a_0, a_n \& b_n$ 3.9 Simple problems (Odd function, even function, x, x^2, e^{+x}, e^{-x}) on finding a Fourier Series with continuous interval only 3.10 Advantages or applications of Fourier Series **Problem Solving**	**Lectures = 3H** **Lectures = 2H** **Lectures = 3H** **Lectures = 2H**

Activities: Conduct **any one** classroom activity during class lecture for each module.

Module 1: Curvilinear Co-ordinates and Partial Differential Equations:

Activity 1: Practice to solve problems on Curvilinear Coordinate system

Activity 2: Practice to solve problems on **Partial Differential Equations**

Module 2: The Special Theory of Relativity:

Activity 1: Practice to solve problems on **Special Theory of Relativity**

Activity 2: Use the **Special Theory of Relativity to solve**

Module 3: Special Functions & Fourier Series

Activity 1: Solving problems on Practical Harmonic Analysis

Activity 2: Study and calculate Fourier coefficients for different functions.

Reference books:

1. Mathematical methods for physicists, Arfken and Weber, Academic press Newyork, 7th Edition.
2. Mathematical physics, Rajput, Pragati prakashan-1997.
3. Mathematical methods in the physical sciences – Marry L. Boas, John Willy & Sons publication, 3rd Edition-2005.
4. Introduction to special relativity, Robert Resnick, John Wiley & Sons, Inc.-1968.
5. Mathematical physics, B. D. Gupta, Vikas publishing house Pvt. Ltd., 4th edition-2010.
6. Mathematical physics, H. K. Dass, Dr. Rama Varma, S. Chand & Company Pvt. Ltd.,7th Edition-2014
7. The Special Theory of Relativity: A Mathematical Approach-Farook Rahaman, Springer Publication - 2014.

X*****rΩb*****X

T.Y.B.Sc. (Physics) (Sem-V)

PHY-302-MJ : Solid State Physics-I

Lectures: 30 hrs **(Credits-02)**

A) Course Objectives: This course aims to

1) Develop Conceptual Understanding of Crystal structures in Physics.
2) Understand Structure Determination Techniques
3) Understand Band Theory, Electronic and Magnetic Properties of solids.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

1) To understand crystal structures and concepts like Miller indices, interplanar spacing, packing fraction, and reciprocal lattice.
2) To understand the principles of experimental techniques X-ray diffraction and to analyze crystal structures using diffraction.
3) To understand Ewald construction and diffraction conditions in direct and reciprocal lattice.
4) To understand origin of bands and concept of density of states and Fermi energy in solids.
5) To understand electrical and magnetic properties of solids.
6) To apply concepts to numerical and analytical problems in solid state Physics.

C) Instructional design:

1) Lecture method **2)** Tutorial method **3)** Seminars 4) Use of multimedia and online resources

D) Evaluation Strategies :

1) Descriptive or subjective written examinations **2)** Assignments **3)** Tutorials **4)** Seminar or Oral or Viva

E) Course Contents : Theory

Module-1	**Crystalline Solids**	**Lectures = 09**
	Lattice, Basis, Translational Vectors, Primitive Unit Cell, Symmetry Operations, Different types of lattices, Miller indices, Inter Planer spacing, SC, BCC and FCC structures, Packing Fraction, Crystal structures : NaCl, CsCl, KCl, Diamond, ZnS, HCP, Concept of Reciprocal Lattice and its properties, **Problem Solving**	**Lectures = 07** **Lectures = 02**
Module-2	**Crystal Structure Determination**	**Lectures = 09**
	Bragg's Diffraction, Bragg's Law, Experimental X-ray diffraction Methods: The Laue Method, Bragg's Spectrometer, Powder Method (Debye Scherrer method), Analysis of cubic structure by powder method, Ewald's Construction, Bragg's Diffraction condition in direct and reciprocal lattice, **Problem Solving**	**Lectures = 07** **Lectures = 02**

Module-3	Band Theory, Electronic and Magnetism Properties of Solids	Lectures = 12
	Electronic Properties of Solids : Free Electron model, Energy levels and Density of States, Nearly free electron model, Fermi energy, Fermi level, Hall Effect, Mobility, Hall Angle, Numericals **Band Theory of Solids:** Origin of energy gap, Energy bands in Solids, Distinction between metal, semiconductor and insulator, Numericals **Magnetism :** Diamagnetism, Paramagnetism, Ferromagnetism, Hysteresis, Variation of magnetic susceptibility with temperature, Curie Wiess Law, Superconductor as example of perfect diamagnet, **Problem Solving**	**Lectures = 10** **Lectures = 02**

F) REFERENCES:

1. Solid State Physics - S.O.Pillai, 6thEdition, New Age International (P) Ltd, Publisher, (2010).
2. Solid State Physics – Kakani S.L. and Hemrajani C., 4th Edition, S. Chand Publication, (2005).
3. Fundamentals of SolidState Physics – B.S.Saxena, R.C.Gupta and P.N.Saxena, Pragati Prakashan,Meerut, Uttar Pradesh
4. Introduction to Solid State Physics- Charles Kittel, John Wiley and Sons, 7th Edition.
5. Solid State Physics- A.J.Dekker, Macmillan India Ltd, (1998).
6. Solid State Physics- R.K. Puri, V.K. Babbar, S. Chand Publication.
7. Elementary Solid State Physics Principles and Applications - M. Ali Omar, Pearson Education, Inc. and Dorling Kindersley Publishing, (2006)
8. Problems and Solution in Solid State Physics-S.O. Pillai, New Age International (P) Ltd.
9. Solid State Physics - P.K. Palanisamy, Scitech Publications(India) Pvt Ltd, Chennei, 1st Edition, (2004)
10. Solid State Physics: Essential Concepts - David W. Snoke, 2nd Edition, Cambridge University Press
11. Concepts of Modern Physics - Beiser, Arthur
12. Concepts of Modern Physics - 6th ed., McGraw-Hill, (2003)

X*****rΩb*****X

T.Y.B.Sc. (Physics) (Sem-V)

PHY-303-MJ : Electrodynamics-I

Lectures: 30 hrs **(Credits-02)**

A) Course Objectives: This course aims to introduce the foundational aspects of classical electrodynamics, focusing on electric and magnetic field theory, material response, and the qualitative understanding of Maxwell's equations

1) To introduce advanced concepts of electric and magnetic fields beyond the basic level studied in the first year.
2) To study the behaviour of electromagnetic fields in material media.
3) To develop understanding of Maxwell's equations and electromagnetic wave propagation.
4) To build a foundation for higher studies in electrodynamics.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

1) Understand the fundamental concepts of electric and magnetic fields.
2) Identify the behavior of fields in dielectric and magnetic materials.
3) Explain Maxwell's equations and their physical significance.
4) Describe the basic properties of electromagnetic waves.
5) Apply the knowledge of electrodynamics to simple physical systems.

C) Instructional design:

1) Lecture method using board teaching 2) Tutorial method for problem solving
3) Seminars by students 4) Use of multimedia (animations/simulations)
5) Creation of online learning resources

D) Evaluation Strategies :

1) Descriptive written examinations 2) Assignments and problem-solving tasks
3) Seminars, oral presentations, and viva

E) Course Contents : Theory

Module-1	**Electric Fields in Matter & Potential Theory**	**Lectures = 10**
	1.1 Brief revision of Coloumb,s Law, electric field, electrostatic potential & Gauss's law (statement and significance) 1.2 Potential energy of system of charges 1.3 Poisson's and Laplace equations (conceptual) 1.4 Motion of charge particle moving with uniform velocity in constant electric field 1.5 Polarization (**P**), Electric Displacement (**D**), Electric dipole, Electric susceptibility and Dielectric Constant and bound charges 1.6 Bound Volume and Surface Charge densities 1.7 Energy stored in electric field 1.8 Applications: Capacitors with dielectric	**Lectures = 08**
	Problem Solving	**Lectures = 02**

Module-2	Magnetic Fields in Matter & Electrodynamics Basics	Lectures = 12
	2.1 Brief revision of Magnetic field, Magnetic flux 2.2 Biot–Savart law (statement) 2.3 Magnetic field due to steady current 2.4 Motion of charge particle moving with uniform velocity in constant magnetic field. 2.5 Lorentz Force & Ampere's circuital law (Statement) 2.6 Force between two current-carrying conductors 2.7 Magnetic dipole moment and its interaction with magnetic field 2.8 Magnetic vector potential (statement) 2.9 Magnetization (**M**) of matter and Relation between **B**, **H**, and **M** 2.10 Types of magnetic materials (concept) 2.11 Concept of electromagnetic induction, Faradays law, Lenz law (Statement& concept) 2.12Applications : Solenoid & Toroid **Problem Solving**	**Lectures = 9** **Lectures = 03**
Module-3	**Maxwell's Equations & Electromagnetic Waves**	**Lectures = 08**
	3.1 Equation of continuity 3.2 Displacement current and Generalization of Ampere's law 3.3 Maxwell's equations (Differential and Integral form) and their physical interpretation 3.4 Electromagnetic wave equation (qualitative) 3.5 Plane electromagnetic waves 3.6 Transverse nature of EM waves 3.7 Poynting Theorem and Poynting vector 3.8 Applications: Electromagnetic spectrum and communication systems **Problem Solving**	**Lectures = 06** **Lectures = 02**

F) REFERENCES:

1) Introduction to Electrodynamics, David J. Griffiths, Pearson Education.
2) Engineering Electromagnetics, William H. Hayt and John A. Buck, McGraw-Hill Education.
3) Electricity and Magnetism, D. C. Tayal, Himalaya Publishing House.
4) Electricity and Magnetism, Brijlal and N. Subrahmanyam, S. Chand & Company Ltd.
5) Electricity and Magnetism, Edward M. Purcell, McGraw-Hill Education.

X*****rΩb*****X

T.Y.B.Sc. (Physics) (Sem-V)

PHY-304-MJ : Classical Mechanics

Lectures: 30 hrs **(Credits-02)**

A) Course Objectives: This course aims to introduce the **fundamental principles of classical mechanics** and their applications in understanding the motion of particles and systems of particles.

1. To study the **basic concepts of motion, force, energy, and momentum**.
2. To impart knowledge about the **dynamics of particles in central force fields**.
3. To understand the **motion of charged particles in electric and magnetic fields**.
4. To introduce the **Lagrangian and Hamiltonian formulations** of mechanics.
5. To develop the ability to solve **numerical and conceptual problems** in classical mechanics.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

1. Understand the **basic laws and concepts of classical mechanics**.
2. Identify the **physical significance of centre of mass, momentum, and energy conservation**.
3. Explain the **motion of particles under electric, magnetic, and central force fields**.
4. Describe **Kepler's laws and the motion of artificial satellites**.
5. Understand **fundamental concepts of elastic and inelastic scattering**
6. Apply the knowledge of **Lagrangian and Hamiltonian mechanics** to physical systems.
7. Solve **numerical problems related to particle dynamics and constrained systems**.

C) Instructional design:

1. Lecture method for explaining theoretical concepts and derivations.
2. Tutorial method for problem solving and numerical practice.
3. Seminars for student participation and conceptual understanding.
4. Use of Multimedia such as PPTs, animations, and simulations for effective teaching.
5. Creation of online resources like notes, assignments, and reference material for self-learning.

D) Evaluation Strategies :

1. Descriptive written examinations to assess theoretical understanding.
2. Assignments to strengthen conceptual clarity and numerical problem-solving ability.
3. Seminars, Orals, and Viva to evaluate communication skills and depth of subject knowledge.

E) Course Contents : Theory

Module-1	**Motion of Particles**	**Lectures = 10H**
	1.1 Charged Particles: Motion of a charged particle in constant electric, magnetic and electromagnetic field, 1.2 System of particles: Concept of Centre of mass, Conservation of linear momentum, angular momentum, energy of system of	**Lectures = 7**

	particles.(statements only) 1.3 Day to day applications of Classical mechanics, **Problem Solving**	 **Lectures = 3**
Module-2	**Central force Field**	**Lectures= 10H**
	2.1 Central force Field: Definition and Properties of central force field. 2.2 Reduction of two body problem to an equivalent one body problem 2.3 Motion in central force field, 2.4 Kepler's laws of planetary motion and Artificial Satellite 2.5 Elastic and inelastic scattering: Elastic scattering - Laboratory and centre of mass system (2L) **Problem Solving**	**Lectures = 7** **Lectures = 3**
Module-3	**Langrangian and Hamiltonian formulation**	**Lectures= 10H**
	3.1 Limitations of Newton's Law of Motion, 3.2 Constraints and Their Classification, Example of Constrains, degrees of freedom, generalized coordinate, configuration space, 3.3 Principle of Virtual work done, 3.4 D'Almeberts Principle of virtual work, 3.5 Langrangian and Hamiltonian equations, (4L) 3.6 Cyclic coordinates, Phase space **Problem Solving**	**Lectures = 7** **Lectures = 3**

F) REFERENCES:

1) **Classical Mechanics** by J.C. Upadhyaya, Himalaya publishing Houses, 2nd Edition, (2005).
2) **Introduction to Classical Mechanics**byR. G. Takawale, P. S. Puranik, Tata McGraw Hill publishing Company Ltd., New Delhi, (2017).
3) **Classical Mechanics**byNC Rana and PS Joag, Tata McGraw Hill Education Private Limited, New Delhi, (1991).
4) **Classical Mechanics** by P.V.Panat, Alpha Science International Ltd., (2005).
5) **Classical Mechanics**byHerbert Goldstein, Narosa Publishing House, (2018).
6) **Introduction to Classical Mechanics with Problems and Solutions** by David Morin, Cambridge University Press (2009)

X*****rΩb*****X

T.Y.B.Sc. (Physics) (Sem-V)

PHY-305-MJP : Basic Physics Lab-V

Lectures: 60 hrs **(Credits-02)**

Section-I:General Physics (any 12)

1. Moment of Inertia by Bifilar suspension
3. Young's modulus by Koeing method
4. Surface tension of mercury by Ripple method
5. Surface tension liquid by Fergusson method
6. Surface tension of mercury by Quincke's method
7. 'Y' by vibration of wooden scale
8. Determination of wavelength of light by Michelson's interferometer
9. Surface Tension of Mercury by method of Ripples.
10. Viscosity of Liquid by rotating cylinder method.
11. Coefficient of sound absorption
12. 'Y' by Cornu's Method
13. Hall Effect: To measure the Hall coefficient
14. Energy gap of a semiconductor
15. Study of XRD spectrum of any material.
16. Resistivity by Four probe method
17. Platinum resistance thermometer

Section II: Additional Activities to be conducted during the semester (Any-1):

1. Demonstrations: Any 2 demonstrations equivalent to 3 experiments
2. Study tour / Industrial visit / Field visit with report equivalent to 3 experiments
3. Mini project equivalent to 3 experiments
4. Computer aided demonstrations (simulations or animations) (Any 2 demonstrations equivalent to 3 experiments)

Study tour: Student have to participate in study tour organized by department to study about physics in Industry / Company / Organization / Research Institute / Research organization / Small scale industry / University Department and compulsory submitted study tour report equivalent to 3 experiments signed by study tour co-ordinator and HOD of Department.

Note: Students have to perform total 15-experiments (12-experiments from Section-I and 1-activity from Section-II)

OR

Participated in Additional any **one** activity equivalent to **3-experiments** with 15-experiments (12 experiments from Section-I and 3-experiments from Section-II) mentioned above. Total laboratory work with additional one activity should be 15-experiments.

X*****rΩb*****X

T.Y.B.Sc. (Physics) (Sem-V)

PHY-306-MJP : Basic Physics Lab-VI

Lectures: 60 hrs **(Credits-02)**

Section-I: Basic Physics Laboratory (any 12)

GROUP-I: Electronics / Advanced Electronics (any 9)

1. Characteristics of J-FET
2. Design and built astable multivibrator using IC-555/IC-741
3. Half adder /Full adder
4. Integrator and differentiator using IC-741
5. IC 723 as regulated power supply
6. Instrumental amplifier using three OP-AMPs
7. Temperature controller using PT 100 / thermocouple /thermistor temperature sensors
8. Object counter (two digit)
9. Schmitt trigger
10. Study of LVDT
11. Study of R-S flip flop
12. Study of DAC: R-2R ladder type
13. Analog Multiplexer and De-Multiplexer using Ic-4051
14. Characteristics of MOS-FET

GROUP-II: Electrodynamics (any 3)

1. Study of forced oscillations by electromagnetically driven simple pendulum
2. Self-Inductance by Anderson's bridge
3. Core losses in transformers
4. Electromagnetic pendulum
5. Self-Inductance by Maxwell's bridge

Section II: Additional Activities to be conducted during the semester (Any-1):

1. Demonstrations: Any 2 demonstrations equivalent to 3 experiments
2. Study tour / Industrial visit / Field visit with report equivalent to 3 experiments
3. Mini project equivalent to 3 experiments
4. Computer aided demonstrations (simulations or animations) (Any 2 demonstrations equivalent to 3 experiments)

Study tour: Student have to participate in study tour organized by department to study about physics in Industry / Company / Organization / Research Institute / Research organization / Small scale industry / University Department and compulsory submitted study tour report equivalent to 3 experiments signed by study tour co-ordinator and HOD of Department.

Note: Students have to perform total 15-experiments (12-experiments from Section-I and 1-activity from Section-II)

OR

Participated in Additional any **one** activity equivalent to **3-experiments** with 15-experiments (12 experiments from Section-I and 3-experiments from Section-II) mentioned above. Total laboratory work with additional one activity should be 15-experiments.

X***** rΩb *****X

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-351-MJ : Atomic and Molecular Physics-I

Lectures: 30 hrs **(Credits-02)**

A) Course Objectives: This course aims to introduce Atomic and molecular spectroscopy.

1) To study the basic concepts regarding Atomic models and atomic spectra.
2) To impart knowledge about Molecular and Raman spectroscopy.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

1) Understand basic concepts of spectroscopy.
2) Identify the various types of spectra.
3) explain various spectroscopic terms and their significance.
4) able to solve problems in spectroscopy.
5) Apply the knowledge of spectroscopy in various fields like biology, medicine, chemistry, etc.

C) Instructional design:

1) Lecture method. **2)** Tutorial method. **3)** Seminars/Group discussion.
4) Use of Multimedia 5) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents : Theory

Module-1	**Atomic structure**	**Lectures = 05H**
	1. Revision of Bohr's atomic models 2. Vector atom model (Concepts of space quantization and electron spin) 3. Four quantum numbers, Pauli Exclusion Principle, Hund's rule, Aufbau principle 4. Electron configuration, Quantum states, Spectral notations of quantum states. **Problem Solving**	**Lectures = 3** **Lectures = 2**
Module-2	**One and two valence electron systems**	**Lectures = 10H**
	1. Spin-Orbit Interaction Energy, (Single valence electron atom), Energy levels of Na-atom, Selection rules, Spectra of sodium atom. 2. Spectral terms of two electron atoms, terms for equivalent electrons, LS and JJ-coupling schemes (pd configuration only). 3. Singlet-Triplet separations for interaction energy of LS coupling (pd configuration only), Lande's interval rule (Graphical representation of ^3D term only). **Problem Solving**	**Lectures = 7** **Lectures = 3**
Module-3	**Spectroscopy**	**Lectures = 15H**
	Part 1 - Molecular spectroscopy 1. Introduction of molecular spectra and its types 2. Rotational energy levels, Rotational spectra of rigid diatomic molecule 3. Vibrational energy levels 4. PE vs interatomic distance curve, Electronic spectra of molecules, Frank-Condon principle (Concepts only) **Problem Solving**	**Lectures = 3** **Lectures = 2**

	Part 2 - Raman spectroscopy 1. Introduction of Raman effect, Molecular polarizability 2. Classical theory and Quantum theory of Raman Effect 3. Applications of Raman spectroscopy **Problem Solving** **Part 3 - X-ray Spectroscopy** 1. Nature of X rays 2. Discrete and Continuous X ray spectra, Duane and Hunt's Rule 3. X ray emission spectra 4. Mosley's law and its applications **Problem Solving**	**Lectures = 3** **Lectures = 2** **Lectures = 3** **Lectures = 2**

Activities:

1) Spectroscopy simulation

https://phet.colorado.edu/sims/html/molecules-and-light/latest/molecules-and-light_all.html

2) Rutherford's Scattering

https://phet.colorado.edu/sims/html/rutherford-scattering/latest/rutherford-scattering_all.html

3) Hydrogen spectra study

https://phet.colorado.edu/sims/html/models-of-the-hydrogen-atom/latest/models-of-the-hydrogen-atom_all.html

4) Perform various physics experiments virtually using website

https://www.vlab.co.in/broad-area-physical-sciences

F) REFERENCES:

1) Modern Physics by R. Murugeshan, Er. K. Sivaprasath, S. Chand, 2014, Revised edition
2) Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles by Robert Eiseberg, Robert Resnik, Wiley, 2016, 2nd edition
3) Molecular structure and Spectroscopy by G. Aruldhas, PHI, 2015, 2nd edition
4) Fundamentals of Molecular Spectroscopy by Colin Banwell, Elaine McCash, TMH, 4th ed
5) Concepts of Modern Physics by Arthur Baiser, McGraw Hill International, 4th edition
6) Introduction to Atomic spectra by White H. E, McGraw Hill International

X*****rΩb*****X

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-352-MJ : Quantum Mechanics-I

Lectures: 30 hrs **(Credits-02)**

A) Course Objectives:

1. To introduce the fundamental principles and experimental foundations of quantum mechanics.
2. To develop the ability to apply the Schrödinger equation to analyse simple quantum systems and understand their physical behaviour.
3. To familiarize students with operator methods and the mathematical framework used to describe quantum mechanical observables.

B) Learning Course Outcomes (CO): Upon successful completion of the course, students will be able to:

1. Understand the core concepts and experimental basis of quantum mechanics, including wave-particle duality and uncertainty principle.
2. Apply the Schrödinger equation to analyse basic quantum systems such as particle in a deep potential well, step potential and tunnelling phenomena.
3. Interpret the physical significance of wave functions, probability densities and expectation values in quantum systems.
4. Utilize operator formalism, including commutation relations and Hermitian operators to describe measurable physical quantities in quantum mechanics.

C) Instructional design:

1) **Lecture Method:** Concept-based teaching using chalk and board supported by ICT.
2) **Tutorial Method:** Problem-solving sessions and doubt-clearing activities to reinforce understanding of quantum systems.
3) **Seminars:** Student-led presentations on selected topics.
4) **Use of Multimedia:** Use of animations, simulations and visual demonstrations (e.g. wave functions, potential wells, tunnelling) to improve conceptual clarity and student engagement.

D) Evaluation Strategies :

1) Theoretical assessments through college and university examinations focusing on conceptual understanding, derivations, and numerical problem-solving skills.
2) Regular assignments comprising numerical problems and short conceptual questions.
   Evaluation through student presentations, oral examinations, and viva voce to assess conceptual clarity, communication skills, and depth of understanding

E) Course Contents : Theory

Module-1	**Foundations of Quantum Mechanics**	**Lecture = 08**
	1. Historical Background: Black body radiation, photoelectric effect. 2. De Broglie Hypothesis: Matter Waves & the de Broglie Wavelength Relation 3. Davisson and Germer experiment. 4. Wave particle duality. 5. Concept of wave function, wave packet, phase velocity (V_p), group velocity (V_g) and relation between V_p & V_g. 6. Heisenberg's uncertainty principle: statement & physical significance, position-momentum, energy-time and angular forms of uncertainty. 7. Applications of quantum mechanics: semiconductor physics, quantum computing and spectroscopy (In brief). **Problem Solving**	**Lectures = 5** **Lectures = 3**
Module-2	**Schrödinger Formalism &Applications of Schrodinger's Steady state equation**	**Lecture = 15**

	Schrödinger Formalism 1. Physical interpretation of wave function. 2. Requirements of wave function. 3. Schrodinger time dependent equation. 4. Schrodinger time independent equation. (Steady state equation). 5. Probability current density, equation of continuity & its physical significance. 6. Eigen function & Eigen values. 7. Expectation value. 8. Ehrenfest's theorem (Statement Only). **Applications Schrodinger's Steady state equation** 1. Free particle. 2. Step potential. 3. Potential barrier (Qualitative discussion), Barrier penetration & tunnelling effect. 4. Particle in infinitely deep potential well (1D only). **Problem Solving**	**Lectures= 12** **Lectures = 3**
Module-3	**Quantum Mechanical Operators and its Algebra**	**Lecture = 07**
	1. Fundamental operators in quantum mechanics: Position operator, momentum operator, angular momentum and Hamiltonian (total energy) operators. 2. Hermitian operator. 3. Commutator algebra: commutator bracket, properties and identities 4. Commutation relations for position, linear and angular momentum operators, Simultaneous eigen functions. 5. Parity in quantum mechanics: concept of parity, parity operator and its eigenvalue. **Problem Solving**	**Lectures = 4** **Lectures = 3**

F) References:

1. N. Zettili, *Quantum Mechanics - Concepts and applications*, Wiley publication, ISBN: 978-0-470-02679-3
2. Griffiths, David J. *Introduction to Quantum Mechanics*. Upper Saddle River, Pearson Prentice Hall, 2005. ISBN: 9780131118928.
3. Ajoy Ghatak, S. Lokanathan, *Quantum Mechanics: Theory and Applications*, Springer Publication, ISBN 978-1-4020-2130-5
4. G Aruldhas, *Quantum Mechanics*, Phi Learning Private Ltd., ISBN : 97881203363
5. R. Shankar, Ramamurti. *Principles of Quantum Mechanics*. Springer, 2008. ISBN: 9780306447907.
6. Eisberg, Robert M., and Robert Resnick. *Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles*. Wiley, 1985. ISBN: 9780471873730.
7. Liboff, Richard L. *Introductory Quantum Mechanics*. Addison Wesley, 2002. ISBN: 9780805387148.
8. Feynman, Richard P., Robert B. Leighton, and Matthew L. Sands. T*he Feynman Lectures on Physics*. Addison Wesley, 1989. ISBN: 9780201500646.
9. P M Mathews and K Venkatesan, *A Textbook of Quantum Mechanics*, Tata McGraw Hill publication, ISBN. : 9780070146174.
10. Gupta, Kumar & Sharma, *Quantum Mechanics*, Jai Prakash Nath Publications.

X*****rΩb*****X

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-353-MJ : Statistical Mechanics -I

Lectures: 30 hrs **(Credits-02)**

A) Course Objectives: This course aims to introduce the fundamental concepts of classical statistical mechanics.

1. To understand the connection between microscopic states and macroscopic properties.
2. To develop knowledge of ensembles and thermodynamic probability.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

1. Understand the foundations of statistical mechanics.
2. Identify the connection between microscopic states and macroscopic properties.
3. Explain Maxwell-Boltzmann statistics and its significance.
4. Compute partition functions and derive thermodynamic quantities.
5. Apply ensemble theory to physical systems.

C) Instructional design:

1) Lecture method 2) Tutorial method 3) Seminars 4) Use of Multimedia

D) Evaluation Strategies :

1) Descriptive written examinations 2) Assignments 3) Seminars

E) Course Contents : Theory

Module-1	**Basic Concepts of Thermodynamics & Statistics**	**Lectures = 12**
	Mean free path, Definition of Transport phenomenon, Thermodynamic functions: Internal Energy, Enthalpy, Helmholtz function, Gibb's function, Maxwell Relations, Specific heat and latent heat equations, Probability, distribution functions, Random Walk in 1D, Binomial distribution, Calculation of mean values, Probability distribution for large-scale N, Gaussian probability distributions, **Problem Solving**	**Lectures = 9** **Lectures = 3**
Module-2	**Statistical Ensembles**	**Lectures = 12**
	Specification of state of system, Statistical ensembles, Basic Postulates, Probability calculations, Behaviors of density of states, Thermal, Mechanical and general interactions Micro canonical Ensemble (Isolated System), Canonical ensembles, simple application of canonical ensemble (Molecule in an Ideal Gas), **Problem Solving**	**Lectures = 9** **Lectures = 3**
Module-3	**Introduction to Quantum Statistics**	**Lectures = 6**
	Quantum distribution function, Maxwell-Boltzmann's statistics, Bose-Einstein Statistics, Fermi-Dirac	

	Statistics, Comparison of the distributions.	

F) REFERENCES:

1. Fundamentals of Statistical and Thermal Physics: F. Reif, McGraw-Hill International Edition (1985).
2. Fundamentals of Statistical Mechanics: B. B. Laud, New Age International Publication (2003).
3. Statistical Mechanics: R. K. Pathria, Butterworth Heinemann (2nd Edition).
4. Statistical Mechanics: K. Huang, John Willey and Sons (2nd Edition).
5. Statistical Mechanics: Satya Prakash and KedarNath Ram, Nath Publication (2008).
6. Statistical Mechanics: Loknathan and Gambhir.
7. Thermodynamics, Kinetic Theory, and Statistical Thermodynamics: Sears and Salinger.

X*****rΩb*****X

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-354-MJ : Nuclear Physics -I

Lectures: 30 hrs **(Credits-02)**

A) Course Objectives: This course aims to introduce fundamental concepts of nuclear physics, structure, radioactivity, forces, reactions and their technological applications as per NEP 2020 guidelines.

- To study the basic concepts regarding nuclear structure, properties, radioactivity, accelerators and detectors.
- To impart knowledge about nuclear forces, reactions, fission, fusion and nuclear reactor theory.

B) Learning Course Outcomes (CO): Upon completion of the course, the student will be able to,

- Understand the structure and properties of the nucleus, radioactivity and its applications.
- Identify the principles and working of particle accelerators and nuclear radiation detectors.
- Explain nuclear forces, elementary particles and quark model along with their significance.
- Analyze nuclear reactions, Q-value, fission, fusion, chain reaction and the working of nuclear reactors.
- Apply the knowledge of nuclear physics to solve numerical problems based on binding energy, radioactive decay, half-life and semi-empirical mass formula.

C) Instructional design:

- Lecture method using chalk-board and PowerPoint presentations
- Tutorial method for problem-solving sessions
- Seminars on applications of radioactivity and nuclear energy
- Use of Multimedia (animations of accelerators, reactors and nuclear processes)
- Creation of online resources (e-notes, short video lectures on selected topics)

D) Evaluation Strategies:

- Descriptive written examinations (University theory paper + Internal tests)
- Assignments (numerical problems and application-based)
- Seminars, Orals, and Viva

E) Course Contents: Theory

Module-1	Nuclear Structure, Properties of nuclei and Radioactivity	Lectures-12
	Basic concept of nucleus: Composition, Charge, Size, Density (Revision); Nuclear mass, Mass defect, Binding energy, Packing fraction, Systematics of nuclear binding energy, Classification of nuclei, Nuclear stability curve; **Properties:** Nuclear spin, Parity, Statistics of nuclei, Magnetic dipole moment, Electric quadrupole moment; **Radioactivity:** Properties of α, β, γ-rays; Laws of radioactive decay, Half-life, Mean life, Units of activity, Specific activity, Successive disintegration; Radiocarbon dating; Applications of radioactivity (Agricultural, Medical, Industrial,	**Lectures-10**

	Archaeological); **Problem Solving**	 **Lecture-2**
Module-2	**Accelerators, Detectors, Nuclear Forces and Nuclear Models**	**Lectures-10**
	Accelerators: Introduction, Classification, Linear accelerator, Cyclic accelerator (Cyclotron), Accelerators in India (Discussion only); **Radiation Detectors:** Classification, Geiger-Muller counter, NaI(Tl) Scintillation detector; **Nuclear Forces:** Properties, Meson theory of nuclear forces; Elementary particles and Quark model; **Nuclear Models:** Shell model: Evidences, Theory of single particle shell model, Liquid drop model: Weizsacher's semi-empirical mass formula, **Problem Solving**	**Lectures-8** **Lecture-2**
Module-3	**Nuclear Reactions and Reactor Theory**	**Lectures-10**
	Nuclear reactions: Introduction, Conservation laws, Q-value equation, Exoergic and endoergic reactions, Threshold energy, Compound nucleus hypothesis, Nuclear fission & fusion, Stellar energy: Proton-proton cycle and Carbon cycle, Fission Chain reaction; **Nuclear reactor:** Basic components, Critical mass and critical size, Homogeneous and heterogeneous reactors, power reactor, fast breeders, Reactors in India (Discussion only), **Problem Solving**	**Lectures-8** **Lecture-2**

Reference Books:

1. Dr. S. N. Ghoshal, Nuclear Physics, Revised Edition, S. Chand Publication, 2014.
2. D. C. Tayal, Nuclear Physics, Revised Enlarged Edition, Himalaya Publishing House.
3. K.S. Krane, Introductory Nuclear Physics, Wiley India, 1988.
4. B. L. Cohen, Concepts of Nuclear Physics, Tata McGraw Hill.
5. I. Kaplan, Nuclear Physics, 2nd Edition, Narosa, New Delhi, 1989.
6. S.B. Patel, Nuclear Physics: An Introduction, New Age International, 1991.
7. Glenn F.Knoll, Radiation Detection and Measurement: 4th Edition, John Wiley & sons.
8. S.S. Kapoaor and V.S. Ramamurthy, Nuclear Radiation Detectors: New Age International Publishers.

X*****rΩb*****X

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-355-MJP : Basic Physics Lab-VII

Lectures: 60 hrs **(Credits-02)**

Section I: Basic Physics Laboratory (any 12)

GROUP-I: Atomic and Molecular Physics (any 4)

1. Determination of Rydberg's constant
2. Zeeman Effect
3. Llyod's mirror
4. Determination of Resolving Power of grating
5. Determination of wavelength by Constant deviation spectrometer

GROUP-II: Statistical Physics (any 4)

1. Determination of pressure coefficient of air by constant volume thermometer.
2. Verification of Stefan's fourth power law by bulb filament
3. Thermal conductivity by Forbes Method.
4. Thermal conductivity of rubber tube.
5. Thermal diffusivity of Brass.
6. Thermal and Electrical conductivity of Cu.

GROUP-III: Nuclear Physics and Quantum Mechanics (any 4)

1. Characteristics of G.M. tube
2. Inverse square law (γ-rays)
3. e/m by Thomson method
4. Determination of Planck's constant
5. Study of Gaussian distribution by G. M. tube.

Section II: Additional Activities to be conducted during the semester (Any-1):

1. Demonstrations: Any 2 demonstrations equivalent to 3 experiments
2. Study tour / Industrial visit / Field visit with report equivalent to 3 experiments
3. Mini project equivalent to 3 experiments
4. Computer aided demonstrations (simulations or animations) (Any 2 demonstrations equivalent to 3 experiments)

Study tour: Student have to participate in study tour organized by department to study about physics in Industry / Company / Organization / Research Institute / Research organization / Small scale industry / University Department and compulsory submitted study tour report equivalent to 3 experiments signed by study tour co-ordinator and HOD of Department.

Note: Students have to perform total 15-experiments (12-experiments from Section-I and 1-activity from Section-II)

OR

Participated in Additional any **one** activity equivalent to **3-experiments** with 15-experiments (12 experiments from Section-I and 3-experiments from Section-II) mentioned above. Total laboratory work with additional one activity should be 15-experiments.

X***** rΩb *****X

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-356-MJP : Physics Lab-VIII (Project-I)

Lectures: 60 hrs **(Credits-02)**

Guidelines:

It is expected that,

1. The student does work equivalent to about ten (15) laboratory experiments throughout the semester in the third year.
2. One bears in mind that the project work is a practical course and it is intended to develop a set of skills pertaining to the laboratory work apart from the cognition of students. Therefore, the guides should not permit projects that involve no contribution on part of student.
3. The project must have a clear and strong link with the principles of basic physics and/or their applications.
4. The theme chosen should be such that it promotes better understanding of physics concepts and brings out the creativity in the students.
5. The evaluation of the project work must give due credit to the amount of the project work actually done by a student, skills shown by the student, understanding of the physics concepts involved and the final presentation at the time of viva voce.
6. It is also recommended that a teacher will look after Four (4) projects at one time.
7. The student can perform an Experimental/Theoretical related with Physical science / Electronics / Computational project in Physics or interdisciplinary areas under the supervision of guides.
8. The student can learn the basics of the topic chosen for project, to learn how to do literature survey and set up the basic experimental/theoretical and computational techniques needed for the project.
9. The department encourage to students for projects both in experimental and theoretical areas of Physics in collaboration with other institutes and industry.

The Project work shall consist of the following Criterions.

1. Project work is mandatory for all the T.Y.B.Sc. students.
2. All the T.Y.B.Sc. students will have to complete the Project work prescribed by the Board of Studies in Physics of Savitribai Phule Pune University during the VIth Semester.
3. It is expected that the Project work shall consist of Title of Project, Abstract, Objectives, Introduction, Literature survey, Materials and Methods, Experimental, Result and Discussion, Conclusion, and Application, References, etc.

Evaluation weightage:

- University Examination: 30 Marks
- Internal Examination: 20 Marks

X*****rΩb*****X

20) Syllabus of Discipline Specific Elective (DSE) Courses (Major Elective)

Major Elective (Semester V) (4 Credits) (2T+2P)

T.Y.B.Sc. (Physics) (Sem-V)

PHY-310(A)-MJ : Thin Film Technology

Lectures: 30 hrs **(Credits-02)**

A) Course Objectives: This course aims to develop scientific research approach among the students and prepare them for higher studies and career opportunities in Physics and related fields by introducing them with

1. Fundamental concepts of thin films such as definition, difference from bulk materials, nucleation and growth mechanisms, the stages of film formation and the optical, electrical, properties of thin film.
2. Various thin film deposition techniques, including physical and chemical.
3. Various characterization techniques to analyse thin film properties for different applications.
4. Importance and applications of thin films in electronics, optics, magnetic devices, energy systems, biomedical coatings, and industrial sectors.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

1. Understand the thin films, differentiate them from bulk and thick films, and explain nucleation, growth processes, stages of film formation and properties of thin films.
2. Explain and compare various thin film deposition techniques, including physical and chemical methods.
3. Gain knowledge of characterization methods and analyse thin film properties for their applications.
4. Gain problems solving skills related to real-world applications in electronics, optics, energy devices, biomedical fields, and industry, and suggest suitable materials and techniques for specific applications.

C) Instructional design:

1) Lecture method **2)** Tutorial method **3)** Seminars4) Use of Multimedia

5) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents : Theory

Module-1	Fundamentals of Thin Films	Lectures= 8h
	1. Introduction of thin films 2. Difference between bulk, thick and thin film materials 3. Nucleation theory (homogeneous & heterogeneous) 4. Growth mechanisms (island, layer, Stranski–Krastanov)	

	5. Stages of film growth 6. Surface energy and interface energy (overview), 7. Adhesion of thin films 8. Grain size and microstructure of thin films, 9. Epitaxy (homoepitaxy and heteroepitaxy) 10. Properties of thin films (electrical, optical, mechanical, magnetic)	
Module-2	**Thin film deposition Methods**	**Lectures = 8h**
	• Thin film deposition methods and their classification • Physical deposition methods : a) Sputtering b) Thermal evaporation c) Chemical Vapour Deposition • Chemical deposition methods: a) Sol-gel b) Electrochemical deposition c) SILAR d) Chemical Bath Deposition	
Module-3	**Thin film Characterizations**	**Lectures= 8h**
	1. Structural characterization: XRD and EDAX, 2. Surface morphology: SEM and TEM, 3. Spectroscopic Characterization: UV-Vis and IR 4. Electrical properties: Four Probe Method, **5.** Functional groups study: FTIR	
Module-4	**Thin film Applications**	**Lectures= 6h**
	1. Thin film - Thermistor, Strain gauge and Capacitor, 2. Electronics (ICs, sensors) 3. Optical coatings (anti-reflection, mirrors) 4. Magnetic Applications (Audio, video and computer memories, Magnetic read/write heads) 5. Thin film solar cells 6. Energy storage devices 7. Photocatalytic devices 8. Medical and biomedical coatings 9. Industrial applications (automobile, defence)	

F) REFERENCES:

1. Chopra, K.L. (1969) Thin Films Phenomena. McGraw-Hill, New York.

2. Ohring, M. (2002). Materials science of thin films: deposition and structure. Academic press.
3. Goswami, A. (1996). Thin film fundamentals. New age international.
4. Vossen, J. L., & Kern, W. (Eds.). (1991). Thin film processes II (Vol. 2). Gulf Professional Publishing.
5. Maissel, L. I., & Glang, R. (1995). Handbook of thin film technology.
6. Martin, P. M. (2009). Handbook of deposition technologies for films and coatings: science, applications and technology. William Andrew.
7. Pierson, H. O. (1999). Handbook of chemical vapour deposition: principles, technology and applications. William Andrew.
8. Brinker, C. J., & Scherer, G. W. (1990). Sol-gel science: the physics and chemistry of sol-gel processing. Gulf Professional Publishing.
9. Chopra, K. (2012). Thin film device applications. Springer Science & Business Media.
10. Moorthy, S. B. K. (Ed.). (2015). Thin film structures in energy applications. Cham, Switzerland: Springer International Publishing.

X*****rΩb*****X

T.Y.B.Sc. (Physics) (Sem-V)

PHY-310(B)-MJ : Functional Nanomaterials

Lectures: 30 hrs **(Credits-02)**

A) Course Objectives: This course aims to develop scientific research approach among the students and prepare them for higher studies and career opportunities in Physics and related fields by introducing them with

1) Fundamental concepts of nanomaterials
2) Methods of synthesis.
3) Various characterization techniques to analyse properties prepared samples for different applications.
4) Applications of nanomaterials in electronics, optics, magnetic devices, energy systems, biomedical coatings, and industrial sectors.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

1) Understand the nanomaterials.
2) Gain knowledge of characterization methods and analyse properties for their applications.
3) Gain problems solving skills related to real-world applications in electronics, optics, energy devices, biomedical fields, and industry, and suggest suitable materials and techniques for specific applications.

C) Instructional design:

1) Lecture method**2)** Tutorial method**3)** Seminars4) Use of Multimedia

5) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations**2)** Assignments**3)** Seminars, Orals, and Viva

E) Course Contents : Theory

Module-1	**Introduction to nanomaterials:**	**Lectures = 7H**
	• Introduction to Nano-sized materials and Structures • Classification of nanostructured materials • Properties of Nanomaterials: Mechanical, Electrical, Thermal and Optical properties	
Module-2	**Methods for Synthesis of Nanomaterials:**	**Lectures = 8H**
	• Bottom-up and Top-down approaches • Synthesis Methods: a) Thermal Evaporation, b) Sputter deposition, c) Colloidal method, d) Sol-gel Method,	

	e) Chemical Vapour deposition, f) Electrochemical Deposition.	
Module-3	**Characterization Techniques:**	**Lectures= 10H**
	• **Structural characterization :** XRD, EDAX • **Morphological Characterization:** SEM, TEM • **Optical characterization:** UV-Vis, IR • **Magnetic characterization:** VSM	
Module-4	**Applications of nanomaterials**	**Lectures = 5H**
	Nano-electronics, Cosmetics, Medical, Biosensors, Automobiles, Space, Sports, Cloth industry, etc.	

Reference books :

1) Nanotechnology: Principles and Practices by Sulbha Kulkarni, Capital Publishing Co. New Delhi.
2) Introduction to nanotechnology, by C. P. Poole Jr. and F. J. Ownes, Willey Publications.
3) Origin and development of nanotechnology by P. K. Sharma, Vista International publishing house.
4) Nanostructure and nanomaterials synthesis, Properties and applications, by G. Cao, Imperials College Press, London.
5) The chemistry of nanomaterials: Synthesis, properties and applications, C. N. R. Rao, A. Muller, A. K. Cheetham (Eds) Wiley VCH Verlag Gmbh& Co, Weinheim, 2004.

X*****rΩb*****X

T.Y.B.Sc. (Physics) (Sem-V)

PHY-310(C)-MJ : Advanced Electronics

Lectures: 30 hrs **(Credits-02)**

A) Course Objectives: - This course aims to introduce basic electronics.

1) To study the basic concepts regarding Analog and Digital electronics and their usefulness.

2) To impart knowledge about the importance of day-to-day electronics.

B) Learning Outcomes (CO): - Upon completion of the course, the student will be able to,

1) Understand the parameters, characteristics, and workings of transistors.

2) Identify and use various electronic devices like transistors, FET, and op-amp.

3) To understand the electronic circuits and their significance.

4) Define performance parameters Logic gates and its families.

5) Apply the knowledge of analog and digital electronics.

C) Instructional Design: -

1) Lecture method 2) Tutorial method 3) Seminars/ Demo kits. 4) Use of Multimedia

5) Creation of online resources.

D) Evaluation Strategies:-

1) Descriptive written examinations 2) MCQ's based examination 3) Assignments

4) Experiential Learning based activity. 5) Seminars, Orals, and Viva

E) Course Contents : Theory

Module-1	**Applications of Semiconductor Devices**	**Lectures = 10**
	Field Effect Transistor : 1. JFET :Classification, Principle, Working and IV-characteristics 2.MOSFETs : DE-MOSFET and E-MOSFET 3. Applications of FET **Timer IC-555:** 1. Block diagram, working and design 2. Applications of IC-555 **OP-AMP :** 1. Applications as Integrator, Differentiator, Comparator Solving Problems on FET, IC-555, OP-AMP	**Lectures = 8** **Lectures=2**
Module-2	**Flip Flop and Counters**	**Lectures = 8**
	1. Introduction to Flip Flop and Counters 2. RS, D, JK and T-flip flops. 3. Application of FF in Sequential Circuits as Counters and Registers. 4. Asynchronous and Synchronous Counters. (3-bit Counter), 5. Shift Registers and their types of operation -SISO, SIPO, PISO, PIPO (Concepts only).	
Module-3	**Analog and Digital Signal Conditioning**	**Lectures = 12**

	Analog Signal Conditioning: 1. Analog Multiplexer and De-Multiplexer using Ic-4051, 2. Ideal & Practical characteristics of Low Pass, High Pass, band pass and band reject filters 3. Instrumentation amplifier using 3-OP-AMP, 4. Application of Instrumentation Amplifier as thermocouple signal conditioning **Digital Signal Conditioning:** 1. Digital Multiplexer and De-Multiplexer using NAND gate, 2. Priority encoder using Ic-74148, 3. Decoders: 2 to 4 decoder and 3 to 8 Decoder. 4. Signal Converters: • DAC: R-2R ladder type DAC, Binary weighted DAC. • ADC: Single slope ADC, Successive Approximation ADC, Flash ADC. 5. Applications of Analog and Digital Signal Conditioning	**Lectures = 6** **Lectures = 6**

F) REFERENCES:

1. Malvino, Electronic Principles (6th Ed.), Tata McGraw Hill, New Delhi
2. R. P. Jain, Modern Digital Electronics (3rd Ed.), Tata McGraw Hill, New Delhi
3. B. L. Theraja, Basic Electronics - Solid State, S. Chand and Company, New Delhi
4. K. R. Botkar, Integrated Circuits, Khanna Publishers, Delhi
5. C.D. Johnson, Process Control Instrumentation Technology, Pearson Education, 8th edition.
6. Krishna Kant, Computer Based Industrial Control, Eastern Economic Edition
7. Rangan, Mani, Sharma, Instrument of Device System
8. B. C. Nakra, K. K. Chaudhari, Instrument measurement and analysis

X*****rΩb*****X

T.Y.B.Sc. (Physics) (Sem-V)

PHY-311-MJP : Special Physics Lab-I

Lectures: 60 hrs **(Credits-02)**

A) Course Objectives: This course aims to enhance the skill-based capabilities in thin film technology on

1. Hands-on experience in the preparation and deposition of thin films (oxide, semiconductor, and metal) using various physical and chemical thin film deposition techniques
2. To familiarize students with modern thin film characterization methods.
3. To develop the ability to analyze experimental results and correlate thin film properties with applications, such as solar cells, Energy storage devices, magnetic devices, sensors, and electronic components.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

1. Understand how prepare and deposit thin films using various deposition techniques
2. Characterize thin films using techniques like XRD, SEM, AFM, UV-Vis spectroscopy, four-point probe, FTIR, ellipsometry, and profilometer.
3. Analyze and interpret experimental data of thin films from the various applications such as solar cells, sensors, magnetic devices, and electronic components.

C) Instructional design:

1) Experimental methods
2) Field Visit / Survey
3) Seminars
4) Use of Multimedia for Demonstration.
5) Creation of online resources google classroom, Simulation software.
6) Journal writing.

D) Evaluation Strategies :

1) Practical Exam.
2) Assignments/ Mini Projects
3) Industrial / research centre/ university department visit report
4) report based on published article
5) Seminars, Orals, and Viva.

E) Course Contents : Thin Film Technology Practical

Expt. No.	Name of Experiment
Section – I: Preparation of Thin Films (Any – 6)	
1	Prepare semiconductor thin film using sol-gel.
2	Deposit thin film using dip coating and study thickness vs withdrawal speed.
3	Prepare semiconductor thin film using spin coater and study thickness vs spin speed.
4	Deposit semiconductor thin film using chemical bath deposition (CBD).

5	Deposit metal film using electrodeposition method.
6	Prepare semiconductor thin film using SILAR.
7	Prepare semiconductor thin film using spray pyrolysis.
8	Prepare semiconductor thin film / powder using hydrothermal method.
9	Prepare semiconducting powder using Co-precipitation method.
10	Deposit metal thin film under vacuum by Thermal Evaporation (use online demonstration/video).
11	Study sputtering process (use online demonstration/video).
12	Study CVD process and reaction mechanism.
Section – II: Characterization and Application of Thin Films(Any – 6)	
1	Measure thickness using Ellipsometry/ Profilometer / weight difference method
2	Determination of Crystal Structure of given XRD pattern
3	To calculate crystallite size by Scherrer Equation of given XRD pattern
4	To study surface morphology of given SEM image
5	To study surface roughness of given AFM 2D and 3D images
6	To calculate band gap of thin film using UV-Vis spectroscopy
7	To measure resistivity of thin film using Four-point probe method
8	To identify chemical bonds in thin films using FTIR
9	To observe hysteresis loop (using data/software/demo)
10	Study working of magnetic read/write heads (model/video/demo)
11	Measure I–V characteristics of solar cell under light
12	Determine efficiency of given output I-V characteristics graphs of Solar Cell
13	To study the chemical state of any material/compound using X-ray photoelectron spectroscopy (XPS) data.

Activities: (Any one)

1. Prepare report on any thin film applicationbased on published report of current academic year.
2. Visit coating/solar/batteryetc. industry.
3. Visit characterization centre / research centre/ institute/ University department etc.
4. Watch thin film fabrication/characterization videos and make report on it.
5. Prepare report on review article on thin film Applications, synthesis, characterization etc. published in current academic year.
6. Prepare report on Future of Thin Film Technology based on published report of current academic year.

Section III: Additional Activities to be conducted during the semester (Any-1):

1. Study tour / Industrial visit / Field visit with report.
2. Minor projects Industry-Specific Projects (Minimum 15 pages)
3. Demonstrations – Any one demonstrations of other experiments.

Study tour: Student have to participate in study tour organized by department to study about physics in Industry / Company / Organization / Research Institute / Research organization / Small scale industry /

University Department and compulsory submitted study tour report equivalent to 3 experiments signed by study tour co-ordinator and HOD of Department.

Note: Students have to perform total 15-experiments (12-experiments from Section-I& II and 1activity)

OR

Participated in Additional any **one** activity equivalent to **3-experiments** with 15-experiments (12 experiments from Section-I and II and 1-activity from Section-III) mentioned above. Total laboratory work with additional one activity should be 15-experiments.

F) REFERENCES:

1) Elements of X-ray Diffraction: B. D. Cullity and S. R. Stock, Pearson, (2014).
2) Thin Films Technology, Practical Manual for the Laboratory Works, World Scientific Publishing (2022) by Alex Axelevitch
3) Handbook of Thin film Technology, McGraw Hill- 1970 by Leaon I. Maissel and Reinhard Glang,
4) Chemical Solution Deposition of Semiconductor Films, Marcel Dekker (2002), by Gary Hodes

OR

E) Course Contents : Physics of NanomaterialsPractical

Section-I: Experiments

Expt. No.	Name of Experiment (any 12)
1	Synthesis of metallic nanoparticles by any chemical method.
2	Synthesis of Metal Oxide Nanoparticle using different techniques.
3	Synthesis of silver nanoparticles from silver nitrate by colloidal solution method
4	Study of optical absorption of nanoparticles.
5	Determination of crystallite size from X-ray diffraction spectra.
6	Study of optical band gap of nanoparticles from UV-Vis spectra.
7	Determination of grain size from X-ray diffraction spectra.
8	To observe hysteresis loop (using data/software/demo)
9	Synthesis of metallic nanoparticles by any physical method.
10	Determination of absorptance and transmittance from IR spectra.
11	Study surface morphology from SEM image.
12	Study surface morphology from TEM image.
13	Study structural behavior from EDAX spectra.
14	To identify chemical bonds in thin films using FTIR
15	To calculate crystallite size by Scherrer Equation of given XRD pattern
16	To study magnetic behaviour of synthesized materials using VSM

Activities: (Any one)

1. Prepare report on any nanomaterials applicationbased on published report of current academic year.
2. Watch synthesis of nanomaterials /characterization videos and make report on it.
3. Prepare report on review article on nanomaterials Applications, synthesis, characterization etc. published paper.

Section II: Additional Activities to be conducted during the semester (Any-1):

1. Study tour / Industrial visit / Field visit with report.
2. Minor projects Industry-Specific Projects (Minimum 15 pages)
3. Demonstrations – Any one demonstration of other experiments.

Study tour: Student have to participate in study tour organized by department to study about physics in Industry / Company / Organization / Research Institute / Research organization / Small scale industry / University Department and compulsory submitted study tour report equivalent to 3 experiments signed by study tour co-ordinator and HOD of Department.

Note: Students have to perform total 15-experiments (12-experiments from Section-I and 1-activity equivalent with 3 experiments)

F) REFERENCES:

1) Nanotechnology: Principles and Practices by Sulbha Kulkarni, Capital Publishing Co. New Delhi.
2) Introduction to nanotechnology, by C. P. Poole Jr. and F. J. Ownes, Willey Publications.
3) Origin and development of nanotechnology by P. K. Sharma, Vista International publishing house.
4) Nanostructure and nanomaterials synthesis, Properties and applications, by G. Cao, Imperials College Press, London.
5) The chemistry of nanomaterials: Synthesis, properties and applications, C. N. R. Rao, A. Muller, A. K. Cheetham (Eds) Wiley VCH Verlag Gmbh & Co, Weinheim, 2004.

X*****rΩb*****X

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-360(A)-MJ : LASER Technology

Lectures: 30 hrs **(Credits-02)**

A) Course Objectives: This course aims to introduce laser technology to solve problems in industry.

1. To acquire a thorough understanding of the theory of modern Laser Physics
2. To understand different types of modern lasers and their applications

B) Learning Course Outcomes (CO) : After learning the course the students will be able to

1. Understand to describe and explain fundamental concepts in laser physics.
2. Compare the function and properties of a number of common lasers.
3. Verify properties of material used for laser production.
4. Apply the knowledge of laser in various applications.

C) Instructional design:

1) Lecture method **2)** Tutorial method **3)** Seminars 4) Use of Multimedia

5) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents : Theory

Module-1	**Basics of laser operation and working**	**Lectures = 10**
	Introduction to LASERS: Interaction of radiation with matter, Spontaneous and stimulated emission - Population inversion – metastable state, Threshold condition – Gain profile – super-radiance Laser - Rate equation for 3 level and 4 level systems - conditions for CW and pulsed laser action. Black body radiation - Modes of oscillation - Einstein coefficients - relation between the absorption coefficients and Einstein coefficients - Lifetime of excited state- Line Broadening mechanisms.	
Module-2	**Types of LASERS**	**Lectures =10**
	Liquid lasers: Principle and main components of laser, levels of laser action, continuous wave lasers, construction and working of dye laser. Gas Laser: Principle, working and usefulness of gas laser, He-Ne laser, lasing action in Ion lasers, construction and operation of ion lasers Solid state laser: Ruby Laser (3- level system example), ND: YAG laser (4- level system example). Semiconductor Laser: Principle of semiconductor laser diode, threshold frequency, difference between a diode and laser diode,	

	Characteristics of semiconductor lasers, Semiconductor diode lasers, LED versus Laser diode.	
Module-3	**LASER Applications**	**Lectures = 10**
	Laser applications: Material processing with lasers, interaction mechanism, Lattice heating, Material processing mechanism (Laser Cutting, Laser Welding, Laser Surface Modification) Elementary ideas on application of Laser in Medical Science - Medical lasers, Laser diagnostic, Laser for general surgery, Laser Dentistry. Elementary ideas on -Laser in Optical Communication: Optical source for fiber optical communication, Essential characteristics of Laser in fibre optic communication, Holography	

F) REFERENCES:

1. Laser Principles, Types and Application by KR Nambiar, New Age International.
2. Modern Spectroscopy by J Michael Hollas, Fourth Edition, John Wiley and Sons.
3. Lasers Theory and Applications by K. Thyagarajan and A.K. Ghatak, Mcmillan (1981)
4. Laser Fundamentals, by William T. Silfvast, Cambridge University Press, 2008.
5. Principles of Lasers, by Orazio Svelto; Springer, 2009.
6. Laser Spectroscopy and Instrumentation by W. Demtroder.
7. Industrial Applications of Lasers, by K. Koebner (ed.), Wiley (1984).
8. https://www.me.iitb.ac.in/~ramesh/courses/ME677/me677.html

X*****rΩb*****X

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-360(B)-MJ : Medical Electronics

Lectures: 30 hrs **(Credits-02)**

A) Course Objectives: This course aims to introduce medical electronics;

1. to acquire a thorough understanding of the theory of medical Physics
2. to understand different types of medical instruments and their applications

B) Learning Course Outcomes (CO) : After learning the course the students will be able to

1. to understand the fundamental concepts in medical physics.
2. to study the function and properties of a medical instruments.
3. to verify properties of material used for medical instruments production.
4. to apply the knowledge of medical instruments in various applications.

C) Instructional design:

1) Lecture method **2)** Tutorial method **3)** Seminars 4) Use of Multimedia

5) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents : Theory

Module-1	**Introduction to medical instrumentation**	**Lectures = 6**
	1. Terminology of medical instrumentation, 2. Physiological system of body 3. Sources of bioelectric signals, 4. Origin of bioelectric signals, 5. Nernst equation, 6. Various types of bioelectric signals,	
Module-2	**Biopotential Electrodes and Sensors**	**Lectures = 12**
	Electrodes: 1. Electrode-electrolyte interface, 2. Polarizable and non-polarizable electrodes, 3. Electrodes for ECG, EEG, EMG, **Sensors:** 1. Resistive sensor, 2. Capacitive sensor, 3. Inductive sensor, 4. Piezoelectric sensor, 5. Temperature sensor	

Module-3	Measurements of Pressure and Volume Flow of Blood	Lectures = 12
	1. Direct measurements of blood pressure, 2. Heart sounds, 3. Phonocardiography, 4. Ultrasonic blood flow meter 5. Laser Doppler blood flow meter 6. Cardiac monitor	

F) REFERENCES:

1. Handbook of Biomedical Instrumentation, R.S. Khandpur
2. Medical Instrumentation application design, John G Webster, Houghon Mifflin Co.
3. Introduction to Medical Electronics, Mahi Publication, Ahmadabad
4. Introduction to biomedical equipment technology J. Carr and John M. Brown
5. Introduction to Biomedical Electronics, Joseph DfuBovy, Mc Graw Hill.
6. Clinical Biophysics, P. Narayanan

X*****rΩb*****X

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-361-MJP : Special Physics Lab-II

Lectures: 60 hrs **(Credits-02)**

A) Course Objectives: This course aims to introduce laser technology or medical electronics;

1. to acquire a thorough understanding of the theory of modern Laser Physics or medical electronics
2. to understand different types of modern instruments and their applications

B) Learning Course Outcomes (CO) : After learning the course the students will be able;

1. to understand to describe and explain fundamental concepts of instruments
2. to compare the function and properties of instruments.
3. to verify properties of material used for instruments production
4. to apply the knowledge of laser and medical electronics in various applications.

C) Instructional design:

1) Lecture method **2)** Tutorial method **3)** Seminars 4) Use of Multimedia

5) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents : LASER Technology Practical

Section I: (12 expt. Compulsory and 1 Activity)

Expt. No.	Title of Experiment (any 12)
1.	Measurement of beam divergence of laser.
2.	Study refractive index of glass using Snell's law
3.	Measurement of wavelength of Laser beam using Michelson Interferometer.
4.	Study of Interference in using a Thin Film air wedge
5.	Study refractive index of liquids using Snell's law
6.	Study the Refraction of Index of homogeneous and non-homogeneous Liquids.
7.	Determination of wavelength using Diffraction Grating
8.	Determination of grating element (number of lines per cm)
9.	Thin Film in Interference Using an Air Wedge
10.	Determination of particle size of dust/powder using Laser
11.	Study of scattering of Light with different particles (chalk dust/milk particles)
12.	Study of the interference of light using optical fibers
13.	Determine the focal length of lens using a laser.
14.	Study of Lissajous figures using diode Laser and mirrors
15.	Determination of Planck's constant using LED and laser comparison method
16.	Analyse multiple beam interference and finesse by Fabry–Pérot Interferometer

	study
17.	Study of Newton's Rings with Laser Source determine radius of curvature of a lens.
18.	Study surface roughness using speckle patterns using LASER.
19.	Study the Laser Power of various lasers(Solid/Gas/Liquid)
20.	Demonstrate reflection-based detection using Barcode Scanner
21.	Study of holography using laser source

Section II : Additional Activities to be conducted during the semester (Any-1):

1. Study tour / Industrial visit / Field visit with report.
2. Minor projects Industry-Specific Projects (Minimum 15 pages)
3. Demonstrations – Any one demonstration of other experiments.

References:

1. "Optical electronics" by Ajoy Ghatak and K. Thyagarajan, Cambridge University Press, 1st Edition (2009)
2. "Laser Physics" by Milonni & Eberly, Wiley publication, 1st edition (2010)
3. "Principles of Lasers" by Svelto and Orazio, Springer publication, 4th edition (1998)
4. A Reference Manual and Experiment Guide for use with Industrial Fiber Optics Helium-Neon Lasers and Optics Education Sets, 13th Edition, New York State, Department of Education.
5. Fiber Optics and Laser Instrumentation (EIC18201), Lab Manual, IIT, Dhanbad.

OR

Course Contents : Medical Electronics Practical

Section I: (12 Compulsory and 1 Activities)

Expt. No.	Title of Experiment (any 12)
1	Measurement of BP using Mercury sphygmomanometer and digital BP monitor
2	Study of ECG machine: Gain, chart speed arrangements and positioning electrodes
3	Recording of ECG and its analysis.
4	Absorbance using calorimeter/ Absorption spectra using Spectrophotometer.
5	Pulse oxymetry: Measurement of SpO2
6	Use of thermal scanner/Thermal gun to measure body temperature
7	Study of glucometer as a sensor and measurement of BSL
8	Study of EEG machine: Gain, chart speed arrangements and positioning electrodes
9	Study of EMG machine: Gain, chart speed arrangements and positioning electrodes

10	Recording of EEG and its analysis.
11	Recording of EMG and its analysis.
12	Study of Resistive sensor and measurement of resistivity,
13	Study of Capacitive sensor and measurement of capacitance,
14	Study of Inductive sensor and measurement of inductance
15	Study of Piezoelectric sensor and measurement of biopotential
16	Study of Temperature sensor and measurement of temperature
17	Measure Heart sounds and heart rate
18	To study of Phonocardiography
19	Study of Cardiac monitor

Section II : Additional Activities to be conducted during the semester (Any-1):

1. Study tour / Industrial visit / Field visit with report.
2. Minor projects Industry-Specific Projects (Minimum 15 pages)
3. Demonstrations – Any one demonstration of other experiments.

Study tour: Student have to participate in study tour organized by department to study about physics in Industry / Company / Organization / Research Institute / Research organization / Small scale industry / University Department and compulsory submitted study tour report equivalent to 3 experiments signed by study tour co-ordinator and HOD of Department.

Note: Students have to perform total 15-experiments (12-experiments from Section-I and 1 activity from Section-II equivalent to 3-experiments)

References:

1. Handbook of Biomedical Instrumentation, R.S. Khandpur
2. Medical Instrumentation application design, John G Webster, Houghon Mifflin Co.
3. Introduction to Medical Electronics, Mahi Publication, Ahmadabad
4. Introduction to biomedical equipment technology J. Carr and John M. Brown
5. Introduction to Biomedical Electronics, Joseph DfuBovy, Mc Graw Hill.
6. Clinical Biophysics, P. Narayanan

X*****rΩb*****X

21) List of Vocational Skill Courses (VSC):(Each semester: 2 Credits)(P)

T.Y.B.Sc. (Physics) (Sem-V)

PHY-321-VSC-P : Solar PV System: Design, and Maintenance

Lectures: 60 hrs **(Credits-02)**

A) Course Objectives: This course aims to enhance the skill-based capabilities in physics

1) To understand the basics of solar energy and solar PV technology.
2) To learn the components of rooftop solar PV systems.
3) To understand basic system design and installation practices.
4) To study maintenance and troubleshooting methods

B) Learning Course Outcomes (CO): Upon completion of the course, the student will be able to,

1. Explain the working principle of solar PV systems.
2. Identify major components of rooftop solar installations.
3. Perform basic sizing and design calculations.
4. Describe installation and safety procedures.
5. Understand maintenance and fault detection methods

C) Instructional design:

1) Experimental methods **2)** Field Visit / Survey **3)** Use of Multimedia for Demonstration

4) Seminars 5) Creation of online resources Google classroom, Simulation software

6) Journal writing.

D) Evaluation Strategies:

1) Practical Exam. **2)** Assignments/ Mini Projects **3)** Seminars, Orals, and Viva.

E) Course Contents: Practical

Expt. No.	Name of Experiment (any 12)
1.	To Study of On Grid Solar PV System Components.
2.	To Study of Off Grid Solar PV System Components.
3.	To Study of Types of Solar Panels in PV System.
4.	To Study I-V Characteristics and Efficiency of Solar PV Module.
5.	To Study Series and Parallel Connection of PV Modules.
6.	To Study Performance Testing Under Different Conditions Solar Module. (Cloudy, Rainy, Sunny, Hot, Cold Etc.).
7.	To Study Effect of Tilt Angle/Intensity Variation on Output Power.
8.	To Study Shading Effect on PV Modules.
9.	To Study PWM/ MPPT Charge Controllers for Charging Battery in PV System.
10.	To Design/ Assemble & Install Solar Street Light.
11.	To Design DC/AC Box Component's Connections in on Grid PV System.

12.	To Study Earthling and Lighting Protection in PV System.
13.	To Study Different Mounting Structure of PV System.
14.	To Study the Proper Cable Wire, Connectors & Protection Devices in PV System.
15.	To Site Analysis for Proper PV System.
16.	To Design Roof Top Grid Connected PV System for Home/Office for Sectioned Load.
17.	To Design Roof Top Off Grid PV System for Home/Office for Sectioned Load.
18.	To Study the Specification of Solar Panel, Solar Inverter, Charge Controller from Catalogue Data.
19.	To Study the Specification of NET Meter/ Bidirectional Meter/ Generation Meter/Data Loggers Used in PV System.
20.	To Study the Standard Procedures and Norms for Grid Connected Solar PV System Installation.

Activities: Any 3 activities conducted.

1. Cleaning and Preventive Maintenance of Panels
2. Solar PV Monitoring using Arduino/ESP32
3. Design PWM charge controller using IC 555 / Arduino.
4. Earthling Resistance Measurement & Insulation Resistance Testing in PV System
5. Study and analyze the grid connected electricity bill of rooftop PV system.
6. Field visit and make report on your nearest Solar Park.
7. Compare different Solar product such as charge controller, Inverter, Solar Module available in market.
8. List the different Solar energy product funding/ subsidy from government of India/ State government (MH). And make aware at least 20 peoples in your society.

F) REFERENCES:

1. Photovoltaic Systems Engineering, Roger A. Messenger & Jerry Ventre, CRC Press (2005)
2. Solar PV System: Design, Installation, Operation and Maintenance: L. Ashok Kumar and K. Mohana Sundaram, Nova Science Pub Inc **(2021).**
3. Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers, C.S. Solanki, Prentice Hall India Learning Private Limited **(2013).**

X*****rΩb*****X

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-371-VSC-P : Modern Electric Vehicle Technology

Lectures: 60 hrs **(Credits-02)**

A) Course Objectives: This course is designed to provide students with an understanding of the basic concepts and practical aspects of electric vehicles, while helping them develop skills related to EV systems, components and their applications.

1) To introduce the basic concepts and different types of electric vehicles.
2) To develop understanding of major EV components such as battery, motor, controller, charger and BMS.
3) To explain basic electrical systems, wiring, and safety practices used in EVs.
4) To apply fundamental physics concepts in analyzing EV performance.
5) To develop practical skills related to testing, measurement and basic maintenance of EV systems.
6) To provide exposure to real-world EV technology through field visits and interaction with technicians.
7) To create awareness about recent developments and future trends in EV technology.

B) Learning Course Outcomes (CO) : After completing this course, students will be able to:

1) Explain different types of electric vehicles and their applications.
2) Identify major EV components and describe their functions.
3) Understand basic wiring and electrical connections used in EVs.
4) Perform simple electrical measurements using standard instruments.
5) Apply basic calculations to estimate EV parameters such as range, energy consumption and charging time.
6) Describe the working of systems such as BLDC motor, controller and throttle.
7) Identify common faults and suggest simple troubleshooting methods.
   Understand practical aspects of EV maintenance through field exposure.
8) Compare different battery technologies used in EVs.
9) Develop basic technical and problem-solving skills related to EV systems.

The course is designed to provide basic employability skills in the field of electric vehicle technology.

C) Instructional design:

1) Experimental method. 2) Case Studies / Survey / Industrial Visit.
3) Seminars & Case study. 4) Use of Multimedia for demonstrations.
5) Creation of Online Resources / Virtual Lab Practicals.6) Journal Writing

D) Evaluation Strategies :

1) Practical Examination.2) Assignments / Case Studies / Showroom Visit.

3) Seminars, Orals and Viva.

E) Course Contents : Practical

NB: Students shall perform ;

- any 4 practical from sections A,
- any 4 practical from sections B,
- any 3 practical from sections C,
- any 1 practical from sections D,

Total =12 practical

Furthermore, students are required to complete any 3 activities from Section F.

Total: 15 practical (12 Practical + 3 Activities)

Section A. Basic & EV Types Practical

Description:

This section introduces students to the basic concepts of electric vehicles. It includes different types of EVs, their main components, battery basics, wiring, and charging systems. It helps students build a strong foundation before moving to advanced topics.

Expt. No.	Name of Experiment (any 4)
1	**Study of types of electric vehicles (BEV, HEV, PHEV, FCEV)** (Method: Collect information about different EV types and compare their working principles, energy sources and applications using charts or diagrams.)
2	**Comparative analysis of EV types (2-wheelers, 3-wheelers & 4-wheelers)** (Method: Compare vehicle types based on parameters such as battery capacity, range, cost and usage. Present the comparison in tabular form.)
3	**Identification and study of EV components** (Method: Observe actual components or images and identify their function and role in the EV system. Prepare labeled diagrams.)
4	**Study of Lithium-ion Battery used in Electric Vehicles** (Method: Students will study the basic construction and working of a lithium-ion battery using charts, models, or reference material. Important parameters such as voltage, capacity (Ah), energy (Wh) and applications in EVs will be noted. Students will draw a simple diagram and write their observations.)
5	**Study of EV wiring diagram (for two-wheeler/3-wheelers/4-wheeler)** (Method: Draw the wiring diagram of a basic EV system and explain the flow of electrical connections.)
6	**Study of battery management system (BMS)**

	(Method: Study the functions of BMS such as protection, monitoring and balancing using diagrams or case examples.)
7	**Study of EV charger (AC to DC conversion)** (Method: Draw a block diagram of charger and explain the conversion of AC supply into DC for battery charging.)
8	**Study of Sensors Used in Electric Vehicles and their Applications** (**Method:** Students will study different sensors such as temperature, speed and Hall sensors using charts or demonstrations and explain their functions in EV systems.)

Section B. Physics & Numerical Practicals

Description:

This section focuses on simple calculations and case studies related to EV performance. It helps students connect physics concepts with real-life applications.

Expt. No.	Name of Experiment (any 4)
1	**Estimation of EV range using battery capacity** (Method: Solve multiple case studies using given data, compare results and represent findings using graphs and conclusions.)
2	**Calculation of battery backup time under different load conditions** (Method: Use different load conditions to calculate backup time, prepare tables and plot graphs to analyze variation.)
3	**Measurement of voltage, current and power** (Method: Take readings using a multimeter under different load conditions, calculate power and compare with theoretical values.)
4	**Analysis of energy consumption per kilometer** (Method: Calculate energy consumption for different vehicles, compare efficiency and present results in tabular form.)
5	**Estimation of power requirement based on vehicle load** (Method: Calculate power for different load values, plot graphs and analyze the effect of load on performance.)
6	**Calculation of charging time for different charging methods** (Method: Calculate charging time for different chargers, compare results and include efficiency considerations.)
7	**Study of regenerative braking system in electric vehicles** (Method: Explain the working using diagrams, perform simple calculations for energy recovery and compare with conventional braking.)
8	**Study and Analysis of Charge–Discharge Characteristics of EV Battery**

	(Method: Charge and discharge data of an EV battery will be observed using given data or demonstration. Students will plot voltage versus time graph and analyze charging and discharging behavior of the battery.)
9	**Study and Estimation of State of Charge (SOC) and State of Health (SOH) of EV Battery** (**Method:** Students will use given data to calculate SOC and SOH of a battery. They will analyze battery condition and compare values under different conditions.)
10	**Measurement and Analysis of Battery Capacity and Efficiency of EV Battery** (**Method:** Battery capacity will be calculated using given voltage and current data. Efficiency will be determined by comparing input and output energy and results will be analyzed.)
11	**Study and Analysis of Torque–Speed Characteristics of EV Motor** (**Method:** Given data for different speeds and torque values will be used. Students will plot torque versus speed graph and analyze motor performance under varying conditions.)

Section C. Skill-Based Practicals

Description:

This section focuses on developing practical skills related to electric vehicle systems. Students will study the working of important components such as motors, controllers, and control systems. It also includes basic troubleshooting of EV circuits. These practical help students understand how EV systems operate in real conditions and improve their hands-on abilities.

Expt. No.	Name of Experiment (any 3)
1	**Study of Induction motor and BLDC Motor used in EVs** (Method: Observe the motor, identify its parts and understand its working with the help of diagram or video.)
2	**Study of Throttle Control System** (Method: Understand how throttle input controls speed using basic demonstration or explanation.)
3	**Study of Motor Controller Operation** (Method: Study controller connections and explain its role in controlling motor speed and performance.)
4	**Study and Diagnosis of Basic Wiring Faults in Electric Vehicles** (Method: Students will observe basic wiring faults such as loose connections, damaged wires, or fuse issues. They will identify the fault using simple tools and suggest corrective actions.)

5	**Identification and Troubleshooting of Basic Faults** (Method: Identify simple faults like loose connection or fuse issue and suggest corrective action.)
6	**Study of Basic EV Safety Precautions and Handling** (Method: Students will study basic safety precautions required while working with electric vehicles. This includes safe handling of batteries, avoiding short circuits, use of proper insulation and precautions during charging. Students will observe safety practices through charts, videos, or demonstration and list important do's and don'ts.)

Section D. Showroom / Industry Practicals

Description:

This section provides exposure to real electric vehicles through field visits. Students will visit EV showrooms and service centers to observe actual systems, maintenance practices and working conditions. Interaction with technicians helps students understand real-life problems and solutions in EV technology**.**

Expt. No.	Name of Experiment (any 1)
1	**Field Study of Electric Vehicles at Showroom** (Method: Visit nearby showroom, observe EV components and note down specifications and working features.)
2	**Study of EV Maintenance Practices at Service Center** (Method: Observe servicing procedures and discuss common faults and maintenance practices with technician.)

Section E. Future-Oriented Practical

Description:

This section introduces students to emerging and future technologies in electric vehicles. It focuses on new developments such as advanced battery systems and their comparison with existing technologies. This helps students stay updated with current trends in the EV industry**.**

Expt. No.	Name of Experiment (any 1)
1	**Study and Comparison of Solid-State and Lithium-ion Batteries** (Method: Students will study the basic features of lithium-ion and solid-state batteries using charts or reference material. They will compare parameters such as energy density, safety, charging time, and life cycle. The comparison will be presented in tabular form, followed by a short conclusion.)

Section F: Activities

Description:

This section includes activity-based learning to enhance practical understanding of electric vehicles. Students will perform field-based, analytical, and comparison activities to connect theoretical knowledge with real-world applications.

Expt. No.	Name of activities (any 3)
1	**Study of Charging Infrastructure** (Activity: Students will study different types of EV charging infrastructure such as slow and fast charging. They will compare charging time, cost, and applications, and present the differences in tabular form.)
2	**Comparison of Motors used in EV** (Activity: Compare BLDC motor and induction motor based on performance, efficiency, and application.)
3	**Study of Power Transmission System in EV** (Activity: Study different transmission mechanisms used in EVs and explain their working.)
4	**EV Charging Time Survey** (Activity: Study charging time of different EV models and compare slow and fast charging methods.)
5	**Cost Analysis of Electric Vehicle** (Activity: To compare the running cost of EVs with CNG, petrol and diesel vehicles based on distance and consumption.)
6	**EV Range Analysis** (Activity: Students will study and analyze the range of an electric vehicle using given battery capacity and energy consumption data. They will calculate the expected range and compare it under different conditions such as load and speed.)

F) REFERENCES:

1) Modern Electric Vehicle Technology: C. C. Chan, Oxford university press, (2001).
2) Fundamentals of Electric Vehicles: Sandeep Dhameja, Newnes, (2001).
3) Electric and Hybrid Electric Vehicles Deign fundamentals: Iqbal Husain, CRC Press, (2011).
4) Electric Vehicle Technology Explained: James Larminie and John Lowry, Wiley, (2012).
5) Battery Technology Handbook: H. A. Kiehne, CRC Press, (2003).

X*****rΩb*****X

22) Syllabus of Minor (MN) Courses :

T.Y.B.Sc. (Physics) (Sem-V)

PHY-341-MN : Modern Physics: Concepts and Applications

Lectures: 30 hrs **(Credits-02)**

A) Course Objectives: This course aims to introduce basic concepts of modern physics and their applications in daily life

1. To study the limitations of classical physics and the emergence of quantum theory.
2. To impart knowledge of applications of modern physics in science and technology.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

1. Understand the need for modern physics and its fundamental concepts.
2. Explain basic quantum phenomena in a conceptual manner.
3. Describe atomic structure and related phenomena.
4. Understand nuclear processes and their applications.
5. Apply concepts of modern physics in interdisciplinary fields.

C) Instructional design:

1) Lecture method using board teaching 2) Use of multimedia (animations, simulations)
3) Interactive discussions and examples 4) Student seminars/presentations
5) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations 2) Assignments 3) Seminars, Orals, and Viva

E) Course Contents : Theory

Module-1	**Origin of Modern Physics and Quantum Concepts**	**Lectures = 10**
	• Historical background: Classical theory of light • Corpuscular theory of light (Isaac Newton) • Wave theory of light (Christian Huygens) • Basic properties of light: reflection, refraction (concept only) • Limitations of classical physics and emergence of quantum theory • Black body radiation • Photoelectric effect • Compton effect • Planck's quantum theory • Wave particle duality • de Broglie hypothesis • Heisenberg uncertainty principle	**Lectures = 8**
	Problems Solving	**Lectures = 2**

Module-2	Atomic, Molecular Physics and Spectroscopy	Lectures = 12
	• Bohr model of hydrogen atom • Energy levels and atomic spectra • Quantum numbers (basic concept) • Introduction to molecular energy levels (rotational and vibrational levels – qualitative) • Introduction to spectroscopy (concept and types) • Raman effect (concept, stokes and anti-stokes lines) • Zeeman effect (splitting of spectral lines in magnetic field – qualitative) • Stark effect (splitting in electric field – concept only) • Application : Spectroscopy in chemical analysis Determination of molecular structure Fluorescence in biological systems Applications of lasers Study of stars using spectral analysis	
Module-3	**Nuclear Physics and Applications**	**Lectures = 08**
	• Nuclear structure • Concept of mass defect and binding energy • Qualitative idea of binding energy curve • Radioactivity • Half life and mean life • Nuclear reaction: fusion and fission • Applications : Electricity generation using nuclear energy Medical imagine (X-ray, CT Scan) Radiotherapy Food preservation Carbon dating Problem Solving	**Lectures = 6** **Lectures = 2**

Activities: Conduct any one classroom activity during class lecture for each module.

Module 1: Quantum Physics

Activity 1: Demonstration of determination of Planck's constant using LED or simulation.

Activity 2: Demonstration to illustrate wave–particle duality using simple light interference and photoelectric effect setup/simulation.

Module 2: Atomic Physics

Activity 1: Demonstration of atomic spectra using spectroscope/simulation.

Activity 2: Demonstration of laser using a laser pointer to observe properties such as directionality and coherence (qualitative).

Module 3: Nuclear Physics

Activity 1: Demonstration to understand radioactivity using G.M. counter (or simulation/video).

Activity 2: Discussion on applications of nuclear energy and radiation safety.

F) REFERENCES:

1. Arthur Beiser, Concepts of Modern Physics, 6th ed., Tata McGraw Hill, 2003.
2. S. H. Patil, Elements of Modern Physics, 2nd ed., Tata McGraw Hill, 2007.
3. R. Murugeshan, K. Sivaprasath, Modern Physics, S. Chand Publishing, 2010.
4. B. L. Theraja, Modern Physics, S. Chand Publishing, 2005.
5. H. C. Verma, Concepts of Physics, Part II, Bharati Bhawan, 2012.
6. David J. Griffiths, Introduction to Quantum Mechanics, 2nd ed., Pearson Education, 2005.
7. Eisberg, R., Resnick, R., Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, 2nd ed., Wiley, 2006.
8. D. Halliday, R. Resnick, J. Walker, Fundamentals of Physics, 10th ed., Wiley, 2014.
9. G. Aruldhas, Engineering Physics, PHI Learning, 2010.
10. K. S. Krane, Modern Physics, 2nd ed., Wiley India, 2012.

X*****rΩb*****X

23) Field Project (FP) :

T.Y.B.Sc. (Physics) (Sem-V)

Guidelines for Field Project (FP)

Lectures: 60 hrs **(Credits-02)**

Field project work will provide students opportunity to visit and observe situation in rural and urban contexts, students are expected to observe and study actual field situations in socio-economic contexts while doing their field work. It will improve opportunities to understand interconnect between theoretical knowledge and practical applications. Field project is expected to enhance their sensitivity to socio-economic issues and improve their ability of problem solving as well as designing innovative solutions to the existing and emerging problems. Field project component will broaden the possibilities of deeper learning and enhancing research acumen of students. Field project broadens opportunities of social responsibility, environmental sustainability, nation building and peace.

Objectives:

- Align classroom learnings with awareness about socio-economic conditions.
- Provide students with exposure to socio economic conditions and align their experiences with contemporary problems.
- Integrating theoretical and practical modes blended learning under the guidance of their faculty.
- Enhance research skills including knowledge discovery, analytical tools, methodologies, and ethical conduct.
- Facilitate problem-solving, decision-making, teamwork, and collaboration.
- Foster ability to work in team, develop social awareness and nurture human values among students.
- Encourage collaboration between Higher Education Institutes (HEIs), social organization, Government and non-government institutes for better implementation of Field project.

Outcomes:

- Apply concepts learned in classrooms to real-world socioeconomic conditions enhancing their understanding and skills.
- Show insights into the challenges, opportunities and culture of socioeconomic diversity, preparing them for future role as responsible citizens.
- Demonstrate evidence of research aptitude and skills of critical thinking, analytical skills, and ethical research conduct in field work.
- Display problem-solving abilities in making informed decisions in complex scenarios through practical situations.
- Work in teams and collaborate to achieve common goals in the work field environments through collaborative efforts.
- Show integrity in their dealings with their work and the people that they interact with by upholding professional; principles and ethical standards.

Project Report:

All projects should be typed on A4 sheets, Font Size 12, Times New Roman, one and a half spacing on executive bond paper. The project report shall have appropriate chapter scheme and be presented in minimum of 20 pages.

Report arrangement :

1) Title Page
   - Title of the Report
   - Name of the Student
   - Seat number
   - Program Title
   - Name of the Guide
   - Month and year of Submission
2) Certificate by the Institute
3) Certificate by Guide
4) Student's Declaration
5) Acknowledgement
6) Abstract : (200-300 words)
7) Table of contents :
8) List of Figures and Tables :
   - Chapter-1: Introduction
   - Chapter2 : Literature Review
   - Chapter 3: Methodology
   - Chapter 4: Field Work Descriptions, Observations and Analysis
   - Chapter 5: Conclusion and Recommendations
9) References
10) Appendices

Evaluation Pattern :

Evaluation during the FP program involves two key components:

a) Internal Evaluation (40%) : by Guide (Marks 20)

Field visit completion, Attendance and interaction = 10 marks
Overall Report quality = 10 marks

Total = 20 marks

b) External Evaluation (60%) : by External Examiner (Marks 30)

Objectives, Literature Review, Methodology, Data Analysis, Conclusion = 15 marks
Overall Project Report Structure = 05 marks
Presentation Skills = 10 marks

Total = 30 marks

Certificate:

Certificate

I hereby certify that Mr./Ms. _____ Student of _____ Institute studying in _____ has completed a project titled _____ in the area of _____specialization for the academic year 20xx (semester-V). To the best of my knowledge the work of the student is original and the information included in the project is correct.

Guide Head of the Department

Declaration :

Declaration

I, Mr./Ms. _____ Student of _____ Institute studying in _____ hereby declare that I have completed the field project entitled _____during the academic year 20xx (semester-V). The report work is original and the information/data included in the report is true emerging from the primary and/ secondary data gathered and analyzed as part of this project. Due credit is extended on the work of Literature/Secondary Survey by endorsing it in the Bibliography as per prescribed format.

Signature of the Student with Date
Name of Student

X*****rΩb*****X

OR

24) Community Engagement and Service or Programme(CEP) :

T.Y.B.Sc. (Physics) (Sem-V)

Guidelines for Community Engagement Programme (CEP)

Lectures: 60 hrs **(Credits-02)**

Objectives:

a. To develop an understanding of community needs and challenges.
b. To equip students with skills to identify problem areas within the community.
c. To guide students in creating effective project proposals.
d. To apply classroom knowledge of courses to field realities and thereby improve the quality of learning.

Field Work:

a. To provide practical experience in implementing community projects.
b. To assess students' ability to apply theoretical knowledge in real-world situations.
c. To develop skills in project management, teamwork, and communication.

Field Report:

All report should be typed on A4 sheets, Font Size 12, Times New Roman, one and a half spacing on executive bond paper. The report shall have appropriate chapter scheme and be presented in minimum of 20 pages.

Report arrangement :

1) Title Page
   - Title of the Report
   - Name of the Student
   - Seat number
   - Programme Title
   - Name of the Guide
   - Month and year of Submission
2) Certificate by the Institute
3) Certificate by Guide
4) Student's Declaration
5) Acknowledgement
6) Abstract : (200-300 words)

Chapter-1:
Chapter2:
Chapter 3: y
Chapter 4: Field Work
Chapter 5: Conclusion and Recommendations

7) References
8) Appendices

Evaluation Pattern :

Evaluation during the CEP programme involves two key components:

a) Internal Evaluation (40%) : by Guide (Marks 20)

Field visit completion, Attendance and interaction = 10 marks

Overall Report quality = 10 marks

Total = 15 marks

b) External Evaluation (60%) : by External Examiner (Marks 30)

Field visits, Field work Reflection and Analysis, Conclusion = 15 marks

Overall Project Report Structure = 05 marks

Presentation Skills and Community Impact Assessment = 10 marks

---

Total = 30 marks

Certificate:

Certificate

I hereby certify that Mr./Ms. _____ Student of _____ Institute studying in _____ has completed a report titled _____ in the area of _____specialization for the academic year 20xx (semester-V). To the best of my knowledge the work of the student is original and the information included in the report is correct.

Guide Head of the Department

Declaration :

Declaration

I, Mr./Ms. _____ Student of _____ Institute studying in _____ hereby declare that I have completed the field report entitled _____during the academic year 20xx (semester-V). The report work is original and the information/data included in the report is true emerging from the primary and/ secondary data gathered and analyzed as part of this project. Due credit is extended on the work of Literature/Secondary Survey by endorsing it in the Bibliography as per prescribed format.

Signature of the Student with Date

Name of Student

X*****rΩb*****X

25) On Job Training (OJT) :

T.Y.B.Sc. (Physics) (Sem-VI)

Guidelines for On Job Training (OJT)

Lectures: 120 hrs **(Credits-02)**

As per university guidelines:

The OJT will provide students opportunity to visit and hands-on-training doing their work. It will improve opportunities to understand interconnect between theoretical Physics knowledge and practical applications. The OJT is expected to enhance their sensitivity to socio-economic issues and improve their ability of problem solving as well as designing innovative solutions to the existing and emerging problems. The OJT component will broaden the possibilities of deeper learning and enhancing research acumen of students. The OJT course is designed to provide practical exposure, skill development, and industrial experience to TYBSc Physics students in accordance with NEP 2020 guidelines. The course aims to bridge the gap between theoretical physics knowledge and its real- life applications in industries, laboratories, research institutes, and entrepreneurship sectors. The OJT shall be conducted under the supervision of the Physics department and concerned industry/organization mentor.

Objectives:

- To provide hands-on training in Physics-related industries, laboratories, and research organizations.
- To develop laboratory skills, analytical abilities, and professional ethics among students.
- To expose students to industrial practices, instrumentation, quality control, and safety procedures.
- To enhance problem-solving, teamwork, communication, and technical skills.
- To familiarize students with modern medical and characterization instruments and industrial processes.
- To create awareness regarding entrepreneurship and employment opportunities in Physics.

Outcomes:

- Apply concepts learned in classrooms to real-world socioeconomic conditions enhancing their understanding and skills.
- Show insights into the challenges, opportunities and culture of socioeconomic diversity, preparing them for future role as responsible citizens.
- Demonstrate evidence of research aptitude and skills of critical thinking, analytical skills, and ethical research conduct in field work.
- Display problem-solving abilities in making informed decisions in complex scenarios through practical situations.
- Work in teams and collaborate to achieve common goals in the work field environments through collaborative efforts.
- Show integrity in their dealings with their work and the people that they interact with by

upholding professional; principles and ethical standards.

Project Report:

All projects should be typed on A4 sheets, Font Size 12, Times New Roman, one and a half spacing on executive bond paper. The project report shall have appropriate chapter scheme and be presented in minimum of 30 pages.

Report arrangement :

1) Title Page
   - Title of the Report
   - Name of the Student
   - Seat number
   - Program Title
   - Name of the Guide
   - Month and year of Submission
2) Certificate by the Institute
3) Certificate by Guide
4) Student's Declaration
5) Acknowledgement
6) Abstract : (200-300 words)
7) Table of contents :
8) List of Figures and Tables :
   - Chapter-1: Introduction
   - Chapter2 : Literature Review
   - Chapter 3: Methodology
   - Chapter 4: Field Work Descriptions, Observations and Analysis
   - Chapter 5: Conclusion and Recommendations
9) References
10) Appendices

Evaluation Pattern :

Evaluation during the FP program involves two key components:

a) Internal Evaluation (40%) : by Guide (Marks 40)

Training completion, Attendance and interaction = 30 marks
Overall Report quality = 10 marks

Total = 40 marks

b) External Evaluation (60%) : by External Examiner (Marks 60)

Objectives, Literature Review, Methodology, Data Analysis, Conclusion = 25 marks
Overall Project Report Structure = 15 marks
Presentation Skills = 20 marks

Total = 60 marks

Certificate:

Certificate

I hereby certify that Mr./Ms. _____ Student of _____ Institute studying in _____ has completed a project titled _____ in the area of _____specialization for the academic year 20xx (semester-V). To the best of my knowledge the work of the student is original and the information included in the project is correct.

Guide Head of the Department

Declaration :

Declaration

I, Mr./Ms. _____ Student of _____ Institute studying in _____ hereby declare that I have completed the field project entitled _____during the academic year 20xx (semester-V). The report work is original and the information/data included in the report is true emerging from the primary and/ secondary data gathered and analyzed as part of this project. Due credit is extended on the work of Literature/Secondary Survey by endorsing it in the Bibliography as per prescribed format.

Signature of the Student with Date
Name of Student

X*****rΩb*****X

X*****rΩb*****X