Board of Studies in Physics

FACULTY OF SCIENCE AND TECHNOLOGY

GONDWANA UNIVERSITY, GADCHIROLI

Syllabus of

M. Sc. Semester III & Semester IV

SUBJECT – PHYSICS

AS PER NEP 2020

Session 2024-2025

LIST OF MEMBERS OF BOS IN PHYSICS

Sr. No.	Name	Member
1.	Dr. Pandurang R. Moharkar Dr. Khatri Mahavidyalaya, Tukum, Chandrapur	Working Chairman
2.	Dr. Sanjay R. Gawali Dr. Ambedkar College of Arts, Commerce and Science, Chandrapur	Member
3.	Dr. Urvashi P. Manik Professor, Sardar Patel College, Chandrapur	Member
4.	Dr. Kundan C. Patil Professor, Janata Mahavidyalaya, Chandrapur	Member
5.	Dr. Dilip S. Choudhary Professor, Dhote Bandhu Science College, Gondia	Member
6.	Dr. Ajay B. Lad Professor, Amolakchand Mahavidyalaya, Yeotmal	Member
7.	Dr. Ashok A. Mistry Professor, Anand Niketan College, Anandwan, Warora	Member
8.	Dr. Vishal G. Dudhe Professor, Shri Shivaji College, Rajura Dist. Chandrapur	Member
9.	Dr. Chhagan D. Mungmode Professor M. G. Arts, Science and Late N. P. Commerce College, Armori	Member
10.	Dr. Ajay D. Dahegaonkar N. S. Science and Arts College, Bhadrawati Dist. Chandrapur	Member
11.	Dr. Kartik N. Shinde N. S. Science and Arts College, Bhadrawati Dist. Chandrapur	Member
12	Dr. Nitin K. Labhshetwar Chief Scientist and Head, Energy and Resource Management Division, CSIR-NEERI, Nagpur	Member
13	Mr. Prashant M. Deshpande Director Global Marketing, Nagpur	Member

Teaching and Examination Schemes:

Teaching and Examination Schemes for Two Year M.Sc. (of four semesters) programme in Subject Physics is as follows:

Table 1: M.Sc. Semester III

Gondwana University, Gadchiroli
NEP 2020 P.G. PROGRAMME SESSION 2024-25
Faculty of Science and Technology
Program Name - M.Sc. Sem-III (Physics)

Sr. No.	Course Category	Course Code	Subject Name	Total Credit	Teaching Scheme (Hrs)			Examination Scheme									Total Marks
								Theory					Practical				
					Th.	Pr.	Total Hrs.	UA	CA	Total Mark	Min. Passing	Duration of Exam (Hrs.)	UA	CA	Total Mark	Min. Passing	
1	Major	03MSCPH 1	Paper 1: Nuclear and Particle Physics	04	04	--	04	80	20	100	40	03	--	--	--	--	**100**
2		03MSCPH 2	Paper 2: Advanced Condensed Matter Physics	04	04	--	04	80	20	100	40	03	--	--	--	--	**100**
3		03MSCPH 3	Paper 3: Atomic and Molecular Physics	04	04	--	04	80	20	100	40	03	--	--	--	--	**100**
4			Practical	02	-	04	04	-	-	-	-	-	30	20	50	25	**50**
5	Major (Elective) Any one from elective	03MSCPH4.1	Paper 4: Ultrasonic and its Applications	02	02	--	02	40	10	50	20	02	--	--	50	25	**50**
		03MSCPH4.2	Paper 4: Optical Fibre and Sensors														
		03MSCPH4.3	Paper 4: Defects in Solids														
		03MSCPH4.4	Paper 4: Digital Electronics and Microprocessors														
		03MSCPH4.5	Paper 4: Fundamentals of Nanoscience and Nanotechnology														
6			Practical	02	-	04	04	-	-	-	-	-	30	20	50	25	**50**
7		03MSCPH 5	Paper 5: Research Project	04	--	08	08	--	--	--	--	--	60	40	100	50	**100**
		Total		**22**	**14**	**16**	**26**	**280**	**70**	**350**	-	-	**120**	**80**	**250**	**125**	**550**

Table 1: M.Sc. Semester IV

Gondwana University, Gadchiroli
NEP 2020 P.G. PROGRAMME SESSION 2024-25
Faculty of Science and Technology
Programme Name - M.Sc. Sem IV (Physics)

Sr. No.	Course Category	Course Code	Subject Name	Total Credit	Teaching Scheme (Hrs)			Examination Scheme									Total Marks
								Theory					Practical				
					Th.	Pr.	Total Hrs.	UA	CA	Total Mark	Min. Passing	Duration of Exam (Hrs.)	UA	CA	Total Mark	Min. Passing	
1	Major	04MSCPH 1	Paper 1: Optics and Optical Instruments	04	04	--	04	80	20	100	40	03	--	--	--	--	**100**
2		04MSCPH 2	Paper 2: Physics of LASER and its Applications	04	04	--	04	80	20	100	40	03	--	--	--	--	**100**
3			Pract-I	02	-	04	04	-	-	-	-	-	30	20	50	25	**50**
4			Prac-II	02	-	04	04	-	-	-	-	-	30	20	50	25	**50**
6	Major (Elective) Any one from Elective	04MSCPH3.1	Paper 3:- Acoustics	04	04	--	04	80	20	100	40	03	--	--	--	--	**100**
		04MSCPH3.2	Paper 3: Advanced Quantum Mechanics														
		04MSCPH3.3	Paper 3: Solar and Photovoltaics														
		04MSCPH3.4	Paper 3: Material Synthesis and Characterization														
		04MSCPH3.5	Paper 3: X-ray Emission and Absorption Spectroscopy														
7		04MSCPH 4	Research Project	06	--	12	12	--	--	--	--	--	90	60	150	75	**150**
	Total			**22**	**12**	**20**	**32**	**240**	**60**	**300**	-	-	**150**	**100**	**250**	**125**	**550**

Abbreviations: DSC: Discipline Specific Core, DSE: Discipline Specific Elective; Research Project: RP. ESE: End Semester Evaluation (UA), CIE: Continuous Internal Evaluation (CA).

M.Sc. Semester III and Semester IV Admission

1. Details of Eligibility for M.Sc. Semester III and Semester IV Admission

The eligibility criterion for admission to M. Sc. Semester III and semester IV are as per the directions of Gondwana University, Gadchiroli.

2. Credit Specifications:

a. Theory Courses: One hour/credit/week (a minimum of 15 hours of teaching per credit is required in a semester.
b. Laboratory/Performance Based Courses: A minimum of 30 hours in laboratory orPerformance Based activities is required in a semester. Performance based activities include Workshop based activities, internship, Apprenticeship; Field based learning, community engagement learning, etc.

c. Each semester will consist of at least 15 weeks of Academic Work equivalent to 90 actual teaching days.

3. Assessment:

Assessment Plan will consist of Continuous Internal Evaluation (CIE) and End Semester Evaluation (ESE) for each course/subject taken together.

(A) Continuous Internal Evaluation (CIE) will be based

a) Attendance of the student during a particular semester
b) An assignment (min. two) based on curriculum to be assessed by the teacher concerned
c) Subject wise class test (min. two) or activities conducted by the teacher concerned with proper rubrics.

(B) Expected classroom activities shall consist of Group Discussion, Seminars, Power Point Presentations, Elocution, Debate, Role Play, Case Studies, Educational Games etc . The teacher is expected to undertake a minimum of four of the aforesaid activity.

(C) The CIE marks will be communicated to the examination cell at the end of each semester, but before the semester end examinations / as instructed by the Examination Cell. These marks will be considered for the declaration of the results.

(D) The record of internal marks, evaluation & results should be maintained for a min. period of three year by the respective department for verification by the competent authority.

4. Standard of Passing

The scope of the course, percentage of passing in Theory and Project and Internal Assessment will be governed as per following rules:

(i) In order to pass the Master of Science (M.Sc.) 1st, 2nd, 3rd, and 4th Semester Examinations, an examinee shall obtain not less than 40 % (Grade 4) marks in each theory course / paper, taking CIE & ESE together. Whereas, for practical / performance-based examination an examinee shall obtain not less than 50 % marks in each practical, taking CIE& ESE together.

(ii) An examinee who is unsuccessful at the examination shall be eligible for admission to the subsequent examinations on payment of a fee prescribed for the examination together with the conditions of the ordinance in force from time to time.

5. General Guidelines

a. The students will have to undertake a research project of 4 credits in Semester III and 6 credits in Semester IV in the second year of the two-year master's degree program.

b. Successful examinees at the M. Sc. Sem I, II, III, and IV Examinations shall be entitled to receive a grade card signed by the Board of Examination and Evaluation of Gondwana

University, Gadchiroli and successful examinees opting for the exit at the end M. Sc. Sem IV Examinations shall, on payment of prescribed fees, receive a Degree certificate in the prescribed format from Gondwana University.

6. Pattern of Question Paper for M.Sc. Semester III & Semester IV Physics

1. Pattern of Question Paper for M.Sc. Semester III & Semester IV Physics Major and Major Elective for 100 Marks.

1. There will be four units in each paper.
2. Maximum marks of each theory paper will be 80.
3. Question paper will consist of five questions, each of 16 marks.
4. Four questions will be on four units with internal choice (One question on each unit).
5. Fifth question will be compulsory with questions from each of the four units having equal weightage and there will be no internal choice.

2. Pattern of Question Paper for M.Sc. Semester III Major Elective for 50 Marks.

1. There will be four units in each paper.
2. Maximum marks of each theory paper will be 40.
3. Question paper will consist of five questions, each of 08 marks.
4. Four questions will be on four units with internal choice (One question on each unit).
5. Fifth question will be compulsory with questions from each of the four units having equal weightage and there will be no internal choice.

7. Instructions for Research Project of M. Sc. Sem III & Sem IV:

a) Instructions for Research Project of M. Sc. Sem III:

(i) In M. Sc. Sem III, the student should select the topic of research in consultation with Research Supervisor. In this semester, the student should focus only on the review of literature of selected topic of research.

(ii) At the time of examination, the student should submit the spiral binding of research project containing introduction of topic of research, review of literature, conclusions and references.

b) Instructions for Research Project of M. Sc. Sem IV:

(i) In M. Sc. Sem IV, the student should focus only on the synthesis, characterization and result and Discussion and conclusions of selected topic of research in Semester III.

(ii) At the time of examination, the student should submit the research project book containing introduction of topic of research, review of literature from semester III and synthesis, characterization, result and discussion, conclusion and references.

8. Instructions for Practical and Research Project Examination:

a. **Instructions for Practical Examination:**

1. The practical examination of M. Sc. Sem III & Sem IV (NEP 2020) is of 50 marks. These 50 marks are distributed into UA (Practical examination) of 30 marks and CA (Internal Assessment) of 20 marks.
2. The practical College Assessment (CA) of M. Sc. Semester III and IV:

Sr. No.	Work Assigned	Marks Distribution (CA)
1.	Seminar on any one practical	10
2.	Viva-voce	05
3.	Report Submission	05
Total		**20**

3. In the practical examination, the student should perform only one experiment.
4. The distribution of UA (Practical examination) of 30 marks is as follows.

Sr. No.	Work Assigned	Marks Distribution (UA)
1.	Record Book	06
2.	Experiment	18
3.	Viva-Voce	06
Total		**30**

5. The minimum passing marks for practical examination is 50% of UA + CA i.e. 25 marks.

b. Instructions for Research Project Examination:

1. The practical examination of Research Project (RP)of M. Sc. Sem III (NEP) is of 100 marks. These 100 marks are distributed into UA (Practical examination) of 60 marks and CA (Internal Assessment) of 40 marks.
2. For the practical examination of RP, the student should prepare ppt of 10 minutes.
3. The distribution of 100 marks (UA + CA) is as follows.

Sr. No.	Work Assigned	Marks Distribution
1.	Report submission	40 (CA)
2.	PPT Presentation	30 (UA)
3.	Viva-Voce	30 (UA)
Total		**100**

4. The minimum passing marks for practical examination is 50% of UA + CA i.e. 50 marks.
5. The practical examination of Research Project (RP) of M. Sc. Sem IV (NEP) is of 150 marks. These 150 marks are distributed into UA (Practical examination) of 90 marks and CA (Internal

Assessment) of 60 marks.

6. For the practical examination of RP, the student should prepare ppt of 10 minutes.
7. The distribution of 150 marks (UA + CA) is as follows.

Sr. No.	**Work Assigned**	**Marks Distribution**
1.	Report submission	60 (CA)
2.	PPT Presentation	45 (UA)
3.	Viva-Voce	45 (UA)
Total		**150**

8. The minimum passing marks for practical examination is 50% of UA + CA i.e. 75 marks.

c. The Practical and Research Project Record of every student shall carry a certificate as shown below, duly signed by the teacher-in-charge and the Head of the Department. If the student fails to submit his / her certified Practical Record duly signed by the Teacher-In-Charge and the Head of the Department, he / she shall not be allowed to appear for the Practical Examination and no Marks shall be allotted to the student.

d. The certificate template shall be as follows:

C E R T I F I C A T E

Name of the college / institution _

Name of the Department: _

This is to certify that this Practical / RP Record contains the bonafide record of the Practical / RP work of Shri / Shrimati / Kumari _ of M. Sc. _ _ _ _ _ _ _ _ _ _ Semester _ _ _ _ _ _ _ _ _ _ during the academic year _ _ _ _ _ _ _ _. The candidate has satisfactorily completed the experiments/ RP prescribed by Gondwana University Gadchiroli for the subject _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Dated _ _ _ / _ _ _ / _ _ _ _ _

Signature of the Teacher / Guide   Head of the Department

1. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

2. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

M.Sc. Semester III (Major) Paper I (03MSCPH 1) Nuclear and Particle Physics

Credit 04 Theory 60 Hrs

Course Objectives:

- To understand the Basic nuclear properties.
- To study the elementary properties of alpha, beta, and gamma and nuclear reactions
- To familiar with the interaction of charged particles and electromagnetic radiation with matter.
- To understand the classification of elementary particles and its properties.

Course Outcomes:

Upon completion of the course successfully, students would be able to

- Explain the nuclear properties, mass, binding energy, nuclear stability, laws of radioactive decay and nature of nuclear force.
- Understand the nuclear reaction mechanism, fission and fusion reactions and nuclear energy.
- Know the principles of nuclear radiation detectors and particle accelerators.
- Have a thorough knowledge of elementary particles.

Unit I **15 Hrs**

Basic nuclear properties; size, radii, shape, and charge distribution, spin, parity, mass, binding energy, semi-empirical mass formula, liquid drop model, nuclear stability, laws of radioactive decay.

Nature of nuclear force, elements of deuteron problem, n-n scattering, charge independence and charge symmetry of nuclear forces. Electric and magnetic moments of nuclei. Evidence for nuclear shell structure, single particle shell model-its validity and limitations.

Unit II **15 Hrs**

Elementary properties of alpha-, beta-, and gamma-, decay of nuclei, their classification, characteristics and selection rules. Elementary theories of alpha-, beta-, and gamma-, decay. Nuclear reactions- conservation laws, mechanism, and cross section. Nuclear reaction mechanism, compound nucleus, direct reactions. Fission and fusion reactions, nuclear energy and elements of nuclear power.

Unit III **15 Hrs**

Interaction of charged particles and electromagnetic radiation with matter. Principles of nuclear radiation detectors: G-M counter, proportional counter, Nal(Tl) Scintillation detector, semiconductor detectors. Elementary principles of particle accelerators: linear accelerators, Van de Graaf, cyclotron, betatron, synchrocyclotron and ion beam accelerators.

Unit IV **15 Hrs**

Classification of elementary particles, strong, weak and electromagnetic interaction. Gellmann-Nishijima formula, Properties of hadrons, baryons, mesons, leptons, and quarks- their quantum numbers, charge, mass, spin, parity, iso-spin and strangeness etc. Symmetry and conservation laws. Elements of quark model and standard model. Higgs boson.

Text Books and Reference Books:

1. Kenneth S. Krane, "Introductory Nuclear Physics", Wiley, New York ,1988.
2. Brian Martin, "Nuclear and Particle Physics", Wiley
3. S. N. Ghoshal, "Atomic and Nuclear Physics", S. Chand
4. D. Griffiths, "Introduction to Elementary Particles", Wiley
5. F. A. Enge, "Introduction to Nuclear Physics", Addison Wesley (1975)
6. W. E. Burcham, " Nuclear Physics", Longman Group Limited(1973)
7. B. Gupta, "Modern Atomic and Nuclear Physics", Books and Allied Pvt. Ltd
8. Subramanyam and Brij Lal, "Atomic and Nuclear Physics", S. Chand
9. Ritesh Kohale, Sanjay J. Dhoble and Vibha Chopra, "Fundamental of Nuclear Physics", Publisher – Bentham Science, ISBN 978981-5049-916

M.Sc. Semester III (Major) Paper II (03MSCPH 2) Advanced Condensed Matter Physics

Credit 04 Theory 60 Hrs

Course Objectives:

- To introduce electronic properties of solids.
- To introduce the concept of formation of bands in solids.
- To acquaint with techniques associated with measurement of band structure and transport phenomena in solids.
- To familiarize the concept of lattice vibration and their role in thermal and optical properties of solids.
- To make acquaint the concept of Exotic solids and their electronic properties.

Course Outcomes:

Upon completion of the course successfully, students would be able to

- Recognize diverse types of magnetic properties in solids and understand the concept of lattice vibration.
- Understand the concepts of band and their formation, their importance in classification of solids and different models of band structure calculation.
- Familiarized with optical properties of solids.
- Understand the Structure and Symmetries of Liquids, Liquid Crystals, Amorphous Solids and Special Carbon Solids.

Unit I **15 Hrs**

Free Electron Theory: Drude Model (in detail), Sommerfeld Model (in detail), Electrical Conductivity, Experimental Electrical Resistivity of Metals, Heat Capacity of Electron Gas, Experimental Heat Capacity.

Review of Heisenberg Theory and Exchange Interaction, Spin Waves and Magnons in ferromagnets, Ferromagnetic Anisotropy, Block Wall, Bloch $T^{3/2}$ law, Magnetic Ordering, Magnetic Hysteresis, Anti-ferromagnetism and Super Exchange Interactions, Magnetic resonance, Magnetic Materials.

Unit II **15 Hrs**

Band Structure of Silicon and Germanium, Band Structure of Direct Gap III-V and III-VI semiconductors, Optical Absorption and Excitons, Thermal Population of Bands in Semiconductors, Intrinsic Carrier Density, Impurities and Extrinsic Carrier Density, Degenerate Semiconductors.

Electrical Conductivity of Semiconductors, Disordered Systems and Hoping Conduction, Hall Effect, Magneto-resistance in Two Dimensional Systems, Quantum Hall Effect, Fractional Quantum Hall Effect.

Unit III **15 Hrs**

Lattice Dynamics and Optical Properties of Solids: Inter-atomic Forces and Lattice Dynamics of Simple Metals, Ionic and Covalent Crystals, Optical Phonons and Dielectric Constants, Inelastic Neutron Scattering, Debey-Waller Factor, Anharmonicity, Thermal Expansion and Thermal Conductivity.

Interaction of Electrons and Phonons with Photons, Direct and Indirect Transitions, Absorption in Insulators, Mossbaur Effect.

Unit IV **15 Hrs**

Exotic Solids: Structure and Symmetries of Liquids, Liquid Crystals and Amorphous Solids, Aperiodic Solids and Quasi-crystals, Fibonacci Sequence, Penrose Lattices and their Extension to Three Dimensions, Special Carbon Solids, Fullerenes, Tubules, Formation Characterization of Fullerences and Tubules, Single Wall and Multi-wall Carbon Tubules, Electronic Properties of Tubules, Carbon Nano-tubules, Grapheme.

Text Books and Reference Books:

1. J. Singleton, "Band Theory and Electronic Properties of Solids", Oxford University Press 2014.
2. C. Kittle, "Introduction to Solid State Physics", Wiley India 2019.
3. N. W. Ashcroft and N.D. Mermin, "Solid State Physics", Harcourt Asia Pvt. Ltd. 2001.
4. M.A. Omar, "Elementary Solid State Physics: Principles and Applications", Addison Wesley 2000.
5. K. Yoshida, "Theory of Magnetism", Springer.
6. V. G. Bhide, "Introduction to Mössbauer Effect and Applications", Tata-McGraw-Hill.
7. P. Guetlich, E. Bill, A. Trautwein, "Mossbauer Effect and Transition Metal Chemistry", Springer.

8. S. Chandrashekhar, “Liquid Crystal”, Cambridge University Press 2nd edition.
9. Steinhardt and Ostuiond, “The Physics of Quasicrystals”, World Scientific Publishing Comp.1987
10. Hari Singh Nalwa, “Handbook of Nanostrctured Materials and Nanotechnology (Vol. 1-4)”, Academic Press.

M.Sc. Semester III (Major) Paper III (03MSCPH 3) Atomic and Molecular Physics

Credit 04 Theory 60 Hrs

Course Objectives:

- To understand the quantum state of electrons in atom.
- To explore the concept of NMR and ESR Spectroscopy.
- To study the rotational, vibrational and Raman spectra of diatomic molecules.
- To understand the electronic spectra of diatomic molecules.

Course Outcomes:

Upon completion of the course successfully, students would be able to

- Understand the atomic structure and spectra of one electron system and two electron system.
- Have a thorough knowledge of atomic structure, electron configurations and the behavior of electrons in various atomic systems.
- Understand the various spectroscopic techniques, showcasing the ability to use them for analyzing and characterizing atomic and molecular properties.
- Analyzes consequences to explain electronic, rotational and vibrational spectra of diatomic molecules.

Unit I **15 Hrs**

Quantum states of an electron in an atomic electron spin, spectrum of hydrogen, Helium and alkali atoms, Relativistic corrections for energy levels of hydrogen; Basic principles of interaction of spin and applied magnetic field.

Concepts of NMR spectroscopy, concepts of spin-spin and spin-lattice relaxation, chemical shift; spin-spin coupling between two and more nuclei; chemical analysis using NMR. Mossbauer effect-Recoil less emission of gamma rays, chemical shift, magnetic hyperfine interaction.

Unit II **15 Hrs**

Electron Spin Resonance, experimental setup, hyperfine structure and isotopic shift, width of spectral lines, LS & JJ coupling, Zeeman, Paschen Back & Stark effect. MASER, Principle of MASER action, Amonia gas MASER, Paramagnetic Solid State MASER and comparison between them, Quantum mechanical amplifier. Stimulated emission, Principle of quantum (MASER) amplification.

Unit III **15 Hrs**

Rotational, vibrational and Raman spectra of diatomic molecules, Quantum theory, Molecular polarizability, Intensity alteration in Raman spectra of diatomic molecules, Experimental setup for Raman spectroscopy in the structure determination of simple molecules. Polyatomic molecules, symmetric top molecules and asymmetric top molecules. Hunds rule.

Unit IV **15 Hrs**

Electronic spectra of diatomic molecules, Born Oppenheimer approximation, Vibrational Coarse structure of electronic bands, intensity of electronic bonds, Franck Condon principle, and selection rules, dissociation and predissociation, dissociation energy, rotational fine structure of electronic bands. General treatment of molecular orbitals, Hund's coupling cases.

Text Books and Reference Books:

1. Jeane L. McHale, "Molecular Spectroscopy", CRC Press Taylor and Francis Group.
2. V.G. Bhide, "Mossbauer Spectroscopy", .
3. J. W. Akitt, B. E. Mann, "NMR and Chemistry: An Introduction to Modern NMR Spectroscopy", Fourth Edition 4th Edition, Kindle Edition, CRC Press.
4. E. A. V. Ebsworth, D. W. H. Rankin, S. Cradock, "Structural Methods in Inorganic Chemistry", Well Scientific Publications
5. H. E. White, "Introduction to Atomic Spectra", Paper Back 2019, Mc Graw Hill
6. C. B. Banwell, "Fundamental of Molecular Spectroscopy", 4^{th} Edition, Paper Back 2017, Mc Graw Hill.
7. B. P. Walker and Straughan, "Spectroscopy Vol. I, II and III", Halsted press,1976
8. G.M. Barrow, "Introduction to Molecular Spectroscopy", International Student Edition, Mc Graw Hill.
9. Gerhard Herzberg, "Spectra of Diatomic Molecules", D. Van Nostrand Company, Inc.
10. J. M. Brown, "Molecular Spectroscopy", Oxford Chemistry Primers
11. P. F. Bemath, "Spectra of Atoms and Molecules", Oxford University Press.
12. J. M. Holkas, "Modern Spectroscopy", Wiley.
13. B. S. Saxena, P. N. Saxena, R. C. Gupta and J. N. Mandal, "Fundamentals of Solid State Physics", Pragati Prakashan 2014.

M.Sc. Semester III Practicals Based On Major (Paper I, Paper II & Paper III)
Credit 02 Practical 60 Hrs

List of Experiments of Nuclear and Particle Physics, Advanced Condensed Matter Physics and Atomic and Molecular Physics (Students should perform atleast 5 experiments)

1. To measure the resistivity of a semiconductor by four probe method at two different temperatures and determination of band gap energy.
2. To measure the Hall coefficient of given semiconductor and identify type of semiconductor and determination of charge carrier concentration.
3. Determination of Hall life of "In".
4. To determine the range of Beta-rays from Ra and Cs.
5. To study G-M counter
6. To determine the magnetoresistance by Hall effect
7. To determine the Dielectric constant of given material
8. To study the random decay of nuclear disintegration using dice (or simulation)
9. To measure the adiabatic compressibility of:
   a) Distilled Water
   b) Piezoelectric Crystal
10. To determine the Band Gap Energy of given thermister.
11. To measure the Magnetic Susceptibility by Gouy's method.
12. To study the Hysteresis loop of magnetic material.
13. To study Frank-Hertz Experiment.
14. To study Lattice vibration in Mono/Diatomic lattice.
15. To study Ferroelectric Phase Transition.
16. To study the line spectra on photographed plates/films and calculation of plate factor.
17. To verify Hartman's dispersion formula.
18. To study the sharp and diffuse series of potassium atom and calculation of spin orbit interaction constant.
19. To determine the metallic element in a given inorganic salt.
20. To record the spectrum of CN violet bands and to perform vibrational analysis.
21. To record the visible bands of ALO and to perform vibrational analysis.
22. To photograph and analyze the reddish glow discharge in air under moderate pressure.
23. To photograph the analyze the whitish glow discharge in air under reduced pressure.
24. To perform vibrational analysis of a band system of N_2.
25. To perform vibrational analysis of band system of C_2.
26. To photograph and analyze the line spectrum of Calcium atom.

27. To record/analyze the fluorescence spectrum of a sample.
28. To record/analyze the Raman spectrum of a sample.
29. To study the Hyperfine structure of the green line of mercury.
30. To photograph the (O, O) band of CuH and to perform rotational analysis.
31. Flashing & quenching in Neon Gas.
32. To determine e/m of electron by Thomson method.
33. Analysis of ESR Spectra of transition metals.
34. Analysis of H-atom spectra in minerals.
35. To study E.S.R. of DPPH.
36. To measure the ultrasonic velocity in unknown liquid.

Note: Teacher can introduce new and relevant experiments which are not in the list.

M.Sc. Semester III (Major Elective-1) Paper IV (03MSCPH 4.1) Ultrasonic and its Applications

Credit 02 Theory 30 Hrs

Course Objectives:

- To understand the important topics in contemporary ultrasound physics at a quantitative level.
- To explore the applications ultrasonic in different field with its scientific technology.

Course Outcomes:

Upon completion of the course successfully, students would be able to

- Conceptual understanding of the physics of ultrasound, its types and production and detection of ultrasound.
- Explain the characteristics of ultrasonic waves and transducer.
- Have a deep knowledge of Propagation of ultrasonic waves in materials and ultrasonic instrumentation.
- Know the applications of Ultrasonics in various disciplines.

Unit I 8 Hrs

Introduction – Types of ultrasonics: Longitudinal, transverse, Surface and Lamb waves. Properties of ultrasonics, Production of Ultrasonic waves - Magnetostriction and Piezoelectric methods, Detection of Ultrasonic waves- Acoustic grating, Kundt's method.

Unit II 7 Hrs

Characteristics of ultrasonic waves - Propagation through matter-wave Equation, Characteristics, absorption, reflection and transmission of ultrasonic waves-acoustic impedance and intensity, ultrasonic transducers – piezoelectric & electromagnetic transducers.

Unit III **8 Hrs**

Propagation of ultrasonic waves in materials (gases, liquids, solids) – Absorption and attenuation in solids. Ultrasonic instrumentation - low intensity devices (Interferometer technique), pulse echo overlap and sing around technique.

Unit IV **7 Hrs**

Ultrasonic propagation in pure liquids - low intensity methods for characterizing structure and interaction - high intensity waves - cavitations, emulsification and cleaning, Applications of Ultrasonics in various disciplines.

Text Books and Reference Books

1. Blitz, Jack, “Ultrasonic Methods and Applications”, Newnes Butterworth Public. & Co 1971.
2. M.J. Blandamer, “Introduction to Chemical Ultrasonics”, Academic Press, London.
3. Bemsomcarlin, “Ultrasonics”, McGraw Hill.
4. Rohn Truell, Charles Elbaum, Bruce B. Chick, “Ultrasonic Methods in Solid State Physics”, Academic Press.
5. W.P. Mason, “Physical Acoustics”, Academic Press
6. Baldev Raj, V. Rajendran, P. Palanichami, “Science and Technology of Ultrasonics”, Alpha Science International, 2004.

M.Sc. Semester III (Major Elective -2) Paper IV (03MSCPH 4.2) Optical Fibre and Sensors

Credit 02 **Theory** **30 Hrs**

Course Objectives:

- To deliver the knowledge about optical waveguide and TE, TM mode propagation.
- To gain insight about the basic properties of optical fiber waveguide and their mode analysis.
- To develop elementary problem-solving capability of EM propagation in waveguide and anisotropic medium.

Course Outcomes:

Upon completion of the course successfully, students would be able to

- Have deep understanding of EM wave propagation in symmetric and asymmetric optical wave guide.
- Demonstrate various fabrication and cabling techniques of optical fiber and its application.
- Solve the problems attributed mode propagation attenuation and dispersion of optically bounded EM wave.
- Deliver the knowledge about the type of optical waveguide and anisotropic crystals.
- Understand basics of optical fibers.
- Learn about Fabrication of optical fibers.

Unit I **8 Hrs**

Introduction: The optical fiber, comparison of optical fiber with other inter connectors, concept of an optical waveguide, rays and modes, principle of light guidance in optical wave guides, fiber types, TE modes of symmetric step index planar waveguide, the relative magnitude of longitudinal component of electric and magnetic field.

Unit II **7 Hrs**

Optical fiber waveguides: Scalar wave equation and modes of fiber, modal analysis for step index fiber, fractional power in the cone, modal analysis of parabolic index medium. Attenuation in optical fiber, pulse dispersion in optical fiber losses at fiber splices.

Unit III **8 Hrs**

Optic Fibers Fundamentals Light transmission in optical fibers- principles, optical properties of optical fibers, Fiber materials, Types of Optical fibers, Modes, Losses, Fabrication of optical fibers, Methods and Principle, Biomedical Optical fibers.

Unit IV **7 Hrs**

Cabling and Applications: Material consideration, loss and band width limiting mechanisms, Fiber cable design, example of cable design. Applications: Fiber optic components and devices, fiber optic sensors.

Text Books and Reference Books

1. S. L. Wymer, "Element of Fiber Optics", Regents.
2. A. Ghatak & K. Thyagarajan, "Optical Electronics", Cambridge Univ. Press, Cambridge 1989.
3. G. Keiser, "Optical Fiber Communication", 4th Ed. Tata McGraw Hill, New Delhi 2008.
4. Robert G. Hunsperger, "Integrated Optics: Theory & Technology", Springer, New Delhi 6th Ed., 2009.
5. D. Marcuse, "Theory of Dielectrics Optical Waveguides", 2nd Ed. Academic Press, Inc. 1991.
6. Donald L. Lee, "Electromagnetic Principle of Integrated Optics", 1st Ed. Wiley Eastern, New Delhi, 1986

M.Sc. Semester III (Major Elective-3) Paper IV (03MSCPH 4.3) Defects in Solids

Credit 02 Theory 30 Hrs

Course Objectives:

- To understand the defects in crystalline solids, their effect on properties and methods of characterizing them.
- To study the thermodynamics of defects and defect-interactions and properties which emerge from the movement of defects.

Course Outcomes:

Upon completion of the course successfully, students would be able to

- Learn various types of defects in solid materials.
- Understand various point defects.
- Understand line, surface and volume defects
- Apply knowledge of defects in solid to various applications.

Unit I **7 Hrs**

Introduction to solid state Physics: Crystal structure and symmetry, Crystal lattice and unit cells, Miller indices and crystal planes.

Basic Concepts of Defects: Definition of defects, Classification of defects (point defects, line defects, and planar defects), Intrinsic and extrinsic defects, Thermodynamics of defects, Techniques for studying crystal structures and defects (brief discussion).

Unit II **8 Hrs**

Point Defects: Introduction to point defects, Stoichiometric Defects: Vacancies and Self-interstitials. Impurities and dopants, Schottky defect, Frenkel Defect, calculation of number of Schottky and Frenkel defects at given temperature, Effects of Schottky and Frenkel Defects. Colour centers.

Unit III **7 Hrs**

Line defects: Dislocations and their types, Edge, Screw dislocations, Burgers vector and Burgers Circuit, Mixed dislocations, Unit and Partial Dislocations, Relationship between dislocation line, Slip plane, Burgers vector and slip plane (FCC, HCP and BCC structure). Properties of dislocations – force on dislocation, energy of dislocation, pinned dislocation (These properties without derivation), dislocation density.

Unit IV **8 Hrs**

Surface defects: Types of surface defects: Steps and terraces, Kinks and adatoms, Surface vacancies and adatoms. Grain boundaries with explanation of high angle, low angle, tilt and twin boundaries, stacking fault and Antiphase boundaries.

Volume defects: Cracks, Pores, Inclusions, Voids, Precipitates. Various applications of Defects.

Text Books and Reference Books:

1. R. J. D. Tilley, "Defects in Solids", J. W. Wiley Press 2008
2. A. J. Dekker, " Solid State Physics", Macmillan Publishers India Ltd., New Delhi 2012
3. M. A. Wahab, "Solid State Physics - Structure and Properties of Materials", Narosa Publication, New Delhi 1999.
4. R. L. Singhal, "Solid State Physics", Kedarnath Ramnath and Co.
5. R. K. Puri and V. K. Babbar, "Solid State Physics", S. Chand. Co.
6. J. R. Hook and H. E. Hall, "Solid State Physics", Wiley India
7. S. O. Pillai, "Solid State Physics", New Age International Publishers.

M.Sc. Semester III (Major Elective-4) Paper IV (03MSCPH 4.4) Digital Electronics and Microprocessors

Credit 02 Theory 30 Hrs

Couse Objectives:

1. To understand the Boolean algebra and its various laws
2. To understand basic concept of microprocessors
3. To understand centre processing unit (CPU)
4. To learn about data communication

Course Outcome:

Upon completion of the course successfully, students would be able to

- Familiar with laws of Boolean Algebra and arithmetic circuits.
- Have an elementary idea of combinational and sequential circuits.
- Have a knowledge about microprocessor instructions, program storage, and instruction execution fetch and execute cycles.
- Understand the need for communication networks, Internet and World Wide Web, communication protocols, Local Area Networks, Interconnecting networks, Future of Network Technology

Unit I **7 Hrs**

Boolean algebra, Features of Boolean algebra, Laws of Boolean algebra, Equivalent switching circuit, De-Morgan's theorems. Simplifying logic circuits: NAND-NAND and NOT-NOR networks. Applications of K maps to half adder, full adder. Arithmetic circuits: Multiplexers, demultiplexers : IC 74150 multiplexer and IC 74154 demultiplexer.

Unit II 7 **Hrs**

Overview of Microcomputer organization and operation, Microprocessor evolution and types, Fundamental knowledge of Microprocessor (8085/8086), Architecture and its operation, Basic idea of logic devices for interfacing 8085/8086. Block diagram of microcomputer, general architecture of microprocessor, architecture of 8085, Status flags, and architecture of 8086.

Unit III **8 Hrs**

The parts of microprocessor CPU, memory requirements, numerical data, and representation of characters, microprocessor instructions, program storage, and instruction execution fetch and execute cycles. The instruction set including memory reference, immediate conditional jump-shift, change control, stack and program counter, subroutines, flow charts, masking, simple programs.

Unit IV 8 **Hrs**

Data Communication Computer and Communications, Need for communication networks, Internet and World Wide Web, communication protocols, Local Area Networks, Interconnecting networks, Future of Network Technology

Instruction - format and addressing modes – Assembly language format – Data transfer, data manipulation & control instructions – Programming: Loop structure with counting & Indexing – Look up table - Subroutine instructions modes.

Text Books and Reference Books:

1. P. C. Pitman , "Design of Digital Systems", Galgotia Pub.
2. P. Malvino, "Digital Computer Electronics", TMH.
3. T. L. Floyd, "Digital Fundamentals", Universal Book Stall.
4. Roger L. Tokheim, "Theory and Problems of Digital Principles", TMH.
5. R. P. Jain, "Modern Digital Electronics", TMH.
6. A. P. Mathur , "Introduction to Microprocessor", PHL.
7. L G. A. Korn, "Up and Small Digital Computer Systems for Scientist and Engineers", McGraw Hill.
8. Adam Osborne, "An Introduction to Micro-computer", Galgotia.
9. Adam Osborne, "Introduction top 4 bit and 8 bit Microprocessors",

M.Sc. Semester III (Major Elective -5) Paper IV (03MSCPH 4.5) Fundamentals of Nanoscience and Nanotechnology

Credit 02 **Theory** **30 Hrs**

Course Objectives:

- To understand the fabrication and characterization of nano structured materials by different analytical methods.
- To have the knowledge on the properties of materials at the nanoscale and implementing it for various applications.

Course Outcomes:

Upon completion of the course successfully, students would be able to

- Have the Basic idea about nanomaterials, Nanoscience and nanotechnology
- Understand the thermal, microscopic, electrical and spectroscopic methods of characterization of nanomaterials.
- Explore the applications of nanomaterials and its devices.

Unit I **7 Hrs**

Basic idea about nanomaterials, Nanoscience and nanotechnology,Introduction to quantum physics, electron as waves, wave mechanics, Schrödinger equation and particle in a box, Heisenberg‟s uncertainty principle, Free electron theory (qualitative idea) and its features, Density of states for zero, one, two and three dimensional materials, Quantum confinement, Quantum wells, wires, quantum dots.

Unit II **8 Hrs**

Development of Nanomaterial Physical methods: Bottom up-Ball Milling, Melt mixing, Physical vapour deposition, Ionised cluster beam deposition, Laser pyrolysis, Sputter deposition, Electric arc deposition, Gas evaporation.

Chemical methods: Hydrothermal combustion, bath deposition with capping techniques and top down, Chemical vapour deposition, Sol-gel method, Combustion method, Microwave assisted method, Wet chemical method.

Unit III **7 Hrs**

Features of Nanomaterials Mechanical, Thermal, Electrical, Optical, Magnetic and Structural. Carbon nanostructures- Fabrication, structure, electrical properties and mechanical properties.

Characterization: Characterization by diffraction method. Chemical characterizations: XPS, XAS and EXAFS.

Unit IV **8 Hrs**

Applications of nanomaterial: Electronics and Electromagnetics- magnetic recording, Optics-nanophosphors and photonic crystals Mechanics. Nanomaterial Devices: Quantum dot heterostructure lasers, all optical switching and optical data storage.

Text Books and Reference Books:

1. Sulbha K. Kulkarni, "Nanotechnology: Principles & Practicals", Capital Publishing Co. New Delhi.
2. Carbon Nanotechnology Recent Developments in Chemistry, Physics, Materials Science and Device Applications, -Elsevier Science
3. Guozhong Cao, "Nanostructures & Nanomaterials Synthesis, Properties & Applications", Imperials College Press London.
4. A. S. Edelstein & R. C.Commorata "Nanomaterials: Synthesis, Properties & Applications". Institute of Physics Publishing, Bristol & Philadelphia.
5. C.P. Poole Jr. and F. J.Owens, "Introduction to Nanotechnology", Wiley Student Edition.
6. T. Pradeep, "Nano: The Essentials", McGraw Hill Education.
7. Kartik N. Shinde, S.J. Dhoble, H.C. Swart, and K.. Park , Phosphate phosphor for solid state lighting, , Springer publication in material science series, vol 174, 2012, ISBN 978364234312-4, U.K.

8. H. S. Nalwa, "Handbook of Nanostructures: Materials and Nanotechnology Vol 1-5", Academic Press, Boston.
9. Zikang Tang and Ping Sheng, "Nanoscience and Technology: Novel Structure and Phenomena", Taylor and Francis.
10. Bhushan, "Hand Book of Nanotechnology", Springer

Practicals on Major (Elective)

Credit : 02 Practical 60 Hrs

List of Experiments of Major Elective Paper 4.1 Ultrasonic and its Applications

1. To Determination of the velocity of ultrasonic waves in a non-electrolytic liquid by ultrasonic interferometer.
2. To determine the frequency of an electrically maintained tuning fork by 1. Transverse mode of vibration 2. Longitudinal mode of vibration.
3. To measure the distance using ultrasonic sensors.
4. To calculate the velocity of ultrasonic sound through water media.
5. To determine the acoustical Parameters of a given Liquid.
6. To determine Isentropic compressibility and Excess isentropic compressibility of binary liquid. mixtures using Ultrasonic Interferometer.
7. To determine apparent molal compressibility and partial molar compressibility of urea and KCl/ NaCl/ Na_2SO_4/K_2SO_4 solutions using Ultrasonic Interferometer.
8. To study the solution process of non- electrolyte / electrolyte solutions (water/alcohol/dioxane etc.) by ultrasonic method.
9. To estimate thermodynamic properties of liquids and liquid mixtures from ultrasonic.
10. To measure the velocity and density (thermal expansivity, isothermal compressibility, minternal pressure, solubility parameter and cohesive energy density).
11. To study the interaction in binary liquid mixtures from ultrasonic velocity measurement on the basis Rao and Wada Constant.
12. To determine the intermolecular free length and free volume of pure liquids using ultrasonic velocity and density data.
13. To determine the deviation in sound velocity of binary liquid mixtures.
14. To determine the ultrasonic velocity experimentally and correlate it with theoretical models proposed for liquid mixtures.

List of Experiments of Major Elective Paper 4.2 Optical Fibre and Sensors

1. To determine the numerical aperture of optical fibre.
2. To measure fiber coupling loss and bending loss
3. To determine the mode field diameter of optical fibre.
4. To measure the attenuation, dispersion and bandwidth of optical fibre.
5. To measure attenuation coefficients of optical fibres.
6. To measure chromatic and modal dispersion in optical fibre.
7. To demonstrate temperature pressure or displacement sensing using optical fibres.
8. To calibrate fibre optics temperature sensors.

9. To measure vibration using fibre optic vibration sensors.
10. To calibrate fibre optic humidity sensors.

List of Experiments of Major Elective Paper 4.3 Defects in Solids

1. To study the crystal structures of a given specimen.
2. To study the crystal imperfections in a given specimen.
3. To study the colour centres and thermoluminescence of alkali halides.
4. To determine the energy band gap of a semiconductor by four probe method.
5. Photoconductivity and deep level transient spectroscopic studies of doped and undoped semiconducting materials.
6. To identify the unknown element from a line emission spectra.
7. To determine the lattice parameter ‘a’ of the unit cell of a cubic crystal using X ray diffraction film.
8. To determine Hall coefficient and mobility of charge carriers in a semiconductor.
9. To determine the dielectric constant of a solid.
10. To study the diffusion of impurity in a crystal lattice and its effect on material properties,
11. To study the effect of defects on material structure and properties by using XRD.

List of Experiments of Major Elective Paper 4.4 Digital Electronics and Microprocessors

1. Realization of NOT, AND, OR, EX-OR gates with only NAND and only NOR gates.
2. Karnaugh map Reduction and Logic Circuit Implementation.
3. Implementation of Half-Adder and Half-Subtractor
4. Implementation of Full-Adder and Full-Subtractor.
5. Four Bit Binary Adder
6. Four Bit Binary Subtractor using 1’s and 2’s Complement.
7. MICROPROCESSORS (8085/8086 Assembly Language Programming)
    a. 8 Bit Addition and Subtraction.
    b. 16 Bit Addition.
    c. BCD Addition.
    d. BCD Subtraction.
    e. 8 Bit Multiplication.
    f. 8 Bit Division.
    g. Searching for an Element in an Array.
    h. Sorting in Ascending and Descending Orders.
    i. Finding Largest and Smallest Elements from an Array.

List of Experiments of Major Elective Paper 4.5 Fundamentals of Nanoscience and Nanotechnology

1. Synthesis of metal oxide nanoparticles by wet chemical method.
2. Deposition of thin films by spray pyrolysis technique.
3. Synthesis of inorganic nanomaterials by combustion method.
4. Synthesis of nanomaterials by sol-gel method.
5. Synthesis of conducting polymer nanofibres by chemical oxidation method.
6. Study of optical absorption of nanoparticles.
7. Determination of particle size of nanomaterials from x-ray diffraction.
8. Study of photoluminescence of well known luminescent nanoparticles.
9. Deposition of thin films by spin coating method.
10. Thermoluminescence study of nanomaterials.
11. Deposition of thin films by dip coating technique.
12. Study of particle size effect on luminescence.
13. Electrical characterization of nanostructured materials.
14. Synthesis of metal oxide nanoparticles by hydro-thermal method.
15. Deposition of thin film in vacuum.
16. Electrical resistivity of nanomaterials using four probe method
17. Photoluminescence study of prepared red/blue/green luminescent nanomaterials.
18. Characterization of nanomaterials using SEM/TEM.
19. Computer modelling methods for studying materials on a wide variety of length and time scales.

Note: 1)Teacher can introduce new and relevant experiments which are not in the list of Major (Elective).

2) Student should perform atleast Five experiments.

M.Sc. Semester IV (Major) Paper I (04MSCPH 1) Optics and Optical Instruments

Credit 04 Theory 60 Hrs

Course Objectives:

- To understand the concepts of geometrical Optics.
- To know the phenomenon of interference and diffraction of light and its applications.
- To explore the knowledge of different optical instruments.
- To understand the importance of coherence, Principle of holography and its characteristics.

Course Outcomes:

Upon completion of the course successfully, students would be able to

- Understand the General theory of image formation, Cardinal points of an optical system.
- Familiar with the phenomenon of interference and diffraction of light.
- Know the various optical instruments.
- Understand the concept of Holography and applications of X-rays.

Unit I **15 Hrs**

General theory of image formation, Cardinal points of an optical system, thick lens and lens combination, telescopic combinations, telephoto lens and eyepieces, aberration in images; chromatic aberration, monochromatic aberration and their reductions, a spherical mirrors and correction plates, meniscus lens, entrance and exit pupil, need for multiple eyepiece, Ramsden and Huygens eyepiece, microscope and telescope, astronomical telescope.

Unit II **15 Hrs**

Principle of superposition, coherence optical path retardation, fringes in thin film, localized fringes, two slit interference, Newton's rings and applications, Michelson interferometer and its applications,

Diffraction; Fresenel type- half period zone, rectilinear propogation, straight edge, Fraunhofer type-Diffraction at a slit, half period zone, circular aperature , plane transmission, reflection, blazed and concave grating, resolving power of grating, Reyleigh criterion of resolution, resolving power of prism and grating.

Refraction- refraction in uniaxial crystal, double image prism, plane, circular and elliptical polarized light, Nicols prism, optical rotation in liquid crystals.

Unit III **15 Hrs**

Optical instruments- magnifying glass, principle of camera, pinhole, lens, SLR and DSLR camera, video camera, angular magnification, aperature, camera lucida, collimator and compound microscope, lens, periscope, binocular, field glass, jweller's glass, projector, eyeglasses and its principal, prism spectroscope.

Unit IV **15 Hrs**

Holography: Importance of coherence, Principle of holography and characteristics, Recording and reconstruction, classification of hologram and application, non-destructive testing, optical fibre waveguides (step index, graded index, single mode), attenuation in fibre, couplers and connectors, LED, X-ray –Principle and process of X-ray image (radiographs) production, factors affecting radiographs, Computed Tomography, principle and working of fluoroscopy, principle and working of CT-scanning, Ultrasound, working principle, imaging by us waves, Doppler ultrasound, magnetic resonance imaging, its working principle.

Text Books and Reference Books:

1. Ajay Ghatak, "Optics", McGraw Hill Education India.
2. Jetkins and White, "Fundamental of Optics", Indian Edition.
3. R. Murugeshan, Kiruthignsivaprakash, "Optics and Spectroscopy", S. Chand.
4. Carl A Carlsson and Gudrun AlmCarlsson, "Basic Physics of X-ray Imaging", 1996.
5. Chales De Kahn, "Collaborative Radiology", 2013.

M.Sc. Semester IV (Major) Paper II (04MSCPH 2) Physics of LASER and its Applications

Credit 04 Theory 60 Hrs

Course Objectives:

- To develop understanding of construction and operation of different Laser systems.
- To understand advances in Laser Physics and it's Applications.

Course Outcomes:

Upon completion of the course successfully, students would be able to

- Understand the basic working, principle and operation of different types of Lasers.
- Get exposure to applications of Lasers in different fields.
- Gain insight of intricacies involved in Laser construction and design.
- Develop understanding of Laser pulsing techniques.

Unit I 15 Hrs

History of Laser, Einstein Relation, Stimulated Emission, Population Inversion, Fabry-Parot Etalon (with plane parallel reflector, circular reflector and paraboloid mirror, unstable reflector), Longitudinal and Transfer mode of Laser cavity, Mode of Selection, Gain in Regenerative Cavity.

Unit II 15 Hrs

Principle of Laser action, Optical feedback and Laser Oscillation (Threshold Condition), Three level Laser, Four level Laser, Mode locking, Pulse shortening-Pico second and Femto second operation, Spectral narrowing and stabilization, Gaussian beam and its property.

Unit III 15 Hrs

Principle, Construction, Energy level diagram and working of following Lasers:

Ruby Laser, Nd:YaG Laser, Tunable Solid State Laser, Homo-junction Laser, Helium Neon Laser, Carbon Dioxide Laser, Dye Laser: Spectroscopic properties of Organic molecule and Dye, Excimer Laser.

Unit IV **15 Hrs**

Material Processing, Laser Communication, Holography, Military Applications, Medical Applications, Industrial Applications, Laser Hazards and laser Safety, Infrared Optical Devices, Laser Cooling, Trapping.

Text Books and Reference Books:

1. G.D. Baruah, “Lasers and Nonlinear Optics”, Pragati Prakashan.
2. Satya Prakash, “Laser Systems and Applications”, *A Pragati Edition*.
3. Dr. M.N. Avadhanulu and Dr. P.S. Hemne, “An Introduction to Lasers: Theory and Applications”, S. Chand.
4. H. K. Malik, “Laser-Matter Interaction for Radiation and Energy”, CRC Press (Taylor and Francis) First Edition, 2021.
5. K. Thyagiranajan and A. K. Ghatak, “Laser, Theory and Applications”, Springer.
6. B. B. Laud, “Lasers and Non-Linear Optics”, New Age International Publisher.
7. S. K. Shrivastava, “LASER Systems and Applications”, New Age International Publisher.
8. Orazio Svelto, “Principles of Lasers”, Springer 2010 Fifth Edition .

M.Sc. Semester IV Major Practical I

Credit 02 Practical 60 Hrs

List of Experiments (Students should perform atleast 5 experiments)

1. To determine the wavelength of monochromatic light by Newton’s ring.
2. To determine the radius of curvature of Planoconvex lens light by Newton’s ring.
3. To determine the refractive index of the material of prism by using spectrometer.
4. To determine the dispersive power of prism using mercury lamp.
5. To determine the resolving power of prism.
6. To determine the wavelength of sodium light using a plane transmission grating.
7. To determine the resolving power of a telescope.
8. To determine the wavelength of sodium line using Michelson’s Interferometer.
9. To determine the focal length of long focus convex lens using short focus convex lens.
10. To determine the cardinal points of combination of lenses using nodal nodal slide arrangement.

M.Sc. Semester IV Major Practical II

Credit 02 Practical 60 Hrs

List of Experiments (Students should perform atleast 5 experiments)

1. To determine wavelength of He-Ne LASER using grating element.
2. To determine wavelength of He-Ne LASER using measuring scale/ruler.
3. To determine spot size of LASER using knife edge.
4. To determine divergence of LASER beam.
5. To determine energy and power of LASER beam.
6. To determine diameter of wire using LASER.
7. To measure contamination in liquid sample using LASER beam.
8. Use of LASER in optical fiber communication.
9. To study the total internal reflection using LASER.
10. To study the double slit interference by He-Ne LASER.
11. To study the Polarization nature of LASER beam.
12. To study diffraction by Single Slit/Double Slit/Groove spacing of CD.
13. To study of refractive Index of thin film using LASER.
14. To determine the thickness of thin film sample using LASER.
15. To study LASER as a monochromatic coherent source (To find wedge angle of glass plate.

Note: Teacher can introduce new and relevant experiments which are not in the list.

M.Sc. Semester IV (Major Elective-1) Paper III (04MSCPH 3.1) Acoustics

Credit 04 Theory 60 Hrs

Couse Objectives:

- To understand the basic concept of sound level meter and its application
- To understand classical ray theory and underwater acoustics
- To understand the basic mechanisms of loud speaker and microphone
- To learn about ultrasonic and its applications.

Course Outcomes:

Upon completion of the course successfully, students would be able to

- Have the knowledge about basic sound level meter and sound measurement techniques.
- Understand the concept of electro acoustics and ultrasonic.
- Work in industry and medical field

Unit I **15 Hrs**

Noise Decibels and levels, dB Scales in acoustics, Reference Quantity for acoustic. Power, intensity and pressure, Determination of overall levels from band levels, Basic sound measuring system using sound level meter. Octave band analyzer. Acoustic Calibrator, Definition of Speech interference levels (SIL), Noise criteria for various spaces. Nomogram relating SPL in octave bands to loudness in Tones, Computation of LL and SIL.

Unit II **15 Hrs**

Architectural Acoustics, Classical ray theory. Decay of sound in live and in dead rooms, Measurement of reverberation time. Effect of absorption on reverberation, Sound absorption coefficient, absorbing materials and their uses. Fundamentals of musical scales. Physics of musical instruments. Public address system and music sound system for auditoria. Instruments used for acoustical tests. Underwater acoustics, Velocity of Sound in Seawater, sound transmission loss in seawater. Refraction Phenomena, Masking by noise and by reverberation, Passive detection hydrophone systems.

Unit III **15 Hrs**

Loud Speakers, idealized direct radiator, Typical cone Speaker, Effect of voice coil parameters, Horn Loudspeakers, pressure response, Woofer, midrange and tweeter, Crossover networks, Fletcher Munsion Curves, Baffles; Infinite type, vented type and acoustic suspension type, Microphones, Moving coil type, Carbon microphones, condenser microphones, Cardiod type, Polar response, Rating of microphone responses. Reciprocity theorem and calibration. RIAA equalization Preamplifiers, Tone control circuits, Equalization amplifiers, Noise filters, Dolby Noise Reduction, High Fidelity Stereo amplifiers, Recording and reproduction of sound.

Unit IV **15 Hrs**

Fundamentals of ultrasonic, Acoustics interaction with liquids, Velocity in fluids, Absorption due to heat conduction and viscosity, single relaxation, internal degrees of freedom, Relaxation in binary mixtures, Normal and associated liquid essential difference in low and high amplitude ultrasonic wave propagation of low amplitude waves, ultrasonic generators piezoelectric effect. Propagation in Solids Attenuation due to electron phonon interaction; Phonon-Phonon interaction, Measurement Techniques, optical method, interference method, Pulse method, Sign-around method. Applications of ultra-sound in industrial and medical fields.

Text Books and Reference Books:

1. Kinsler and Fry, "Fundamentals of Acoustics", Wiley Eastern.
2. Leo L. Beranek, "Acoustics", John Wiley and Sons..
3. L. L. Beranek, "Noise Reduction", Peninsula Publishing.
4. J. Blitz, "Fundamentals of Ultrasonic", Plenum.
5. A. B. Bhatia, "Ultrasonic Absorption", New Edition.
6. Don Davis, "Acoustical Test and Measurements", Howard W. Sams.

M.Sc. Semester IV (Major Elective-2) Paper III (04MSCPH 3.2) Advanced Quantum Mechanics

Credit 04 Theory 60 Hrs

Course Objectives:

- To understand the advanced quantum mechanics covering variation method, WKB approximation, perturbation theory,
- To elaborate the symmetry and conservation laws, theory of scattering, system of identical particles, angular momentum and relativistic quantum mechanics.

Course Outcomes:

Upon completion of the course successfully, students would be able to

- Know the use of approximation methods viz variation, time dependent and time independent perturbations.
- Distinguish different approximation methods, to study the structure and properties of many electron systems.
- Understand angular momentum addition rules and CG coefficients.
- Know the concepts of spin and angular momentum, as well as their quantization and addition rules.
- Summarize different types of symmetry, conservation laws and quantum theory of scattering.

Unit I **15 Hrs**

Approximation Methods for Stationary Systems: Time-independent perturbation theory - (a) non-degenerate and (b) degenerate, Variational Method; WKB method and its applications. Time Dependent Perturbation theory, Transition to a continuum of final states-Fermi Golden Rule, Applications, Semi-Classical theory of radiation.

Unit II **15 Hrs**

Angular Momentum: Commutation relations of angular momentum operators. Eigen values, eigenvectors. Ladder operators and their matrix representations. Spin angular momentum and Pauli matrices. Identical particles: Many-particle systems, Exchange degeneracy, symmetric and anti-symmetric wave functions. Pauli exclusion principle. Addition of angular momenta. Clebsch- Gordan coefficients. Wigner -Eckart theorem.

Unit III **15 Hrs**

Symmetry in Quantum Mechanics- Symmetry transformation, Translation in space, Conservation of linear momentum, translation in time, Conservation of energy, Rotation in Space, Conservation of angular momentum, Space inversion, Time Reversal. Relativistic Wave Equations – Klein-Gordon equation, Dirac equation. Properties of Dirac matrices, Plane wave solution of Dirac equation, spin and magnetic moment of the electron.

Unit IV **15 Hrs**

Non-relativistic scattering theory, Differential and Total scattering cross section, Born approximation method with examples of scattering by Coulomb, Gaussian, Square well and Yukawa potentials. Partial wave analysis, optical theorem, phase shift, example of scattering bysquare well potential.

Text Books and Reference Books

1. L. I. Schiff, "Quantum Mechanics", McGraw Hill Higher Education; 3rd revised edition, 1968.
2. Eugen Merzbacher, "Quantum Mechanics", 3rd Ed., Wiley, 1997.
3. J. J. Sakurai, "Modern Quantum Mechanics", Addison-Wesley, 1993.
4. Aurthur Beiser, "Concept of Modern Physics", 6^{th} Ed. Tata McGraw Hill.
5. B. K. Agrawal and Hari Prakash, "Quantum Mechanics", PHI
6. B. H. Bransden & C. J. Joachain, "Quantum Mechanics", Pearson, 2000.
7. Arul Das, "Quantum Mechanics", 2^{nd} Ed. PHI.
8. David J Griffiths, "Introduction to Quantum Mechanics" Pearson, 2015.
9. Ajoy Ghatak, "Quantum Mechanics -Theory and Applications", Trinity, 2015.
10. R. Shankar, "Principles of Quantum Mechanics", 3rd Ed., Springer, 2008.

M.Sc. Semester IV (Major Elective-3)Paper III (04MSCPH 4.3) Solar and Photovoltaics

Credit 04 **Theory** **60 Hrs**

Course Objectives:

- To develop a comprehensive technological understanding in solar PV system components.
- To provide in-depth understanding of design parameters to help design and simulate the performance of a solar PV power plant.

Course Outcomes:

After completion of this course, students will be able to

1. Understand Solar Energy Fundamentals.
2. Learn about Solar Photovoltaic Technologies.
3. Learn Energy Yield Estimation.
4. Understand PV System Economics and Ecology.
5. Evaluate difference between Hybrid organic, Inorganic solar cells, multi-junction solar cells.

Unit I **15 Hrs**

Introduction to Solar Energy: Definition of renewable energy, Comparison with non-renewable sources, Global energy consumption trends. Advantages of solar energy, Environmental benefits, Economic considerations, Nature and characteristics of solar radiation, Solar energy availability and variability, Measurement of solar radiation: pyranometers, pyrheliometers, Discussion on the environmental benefits and challenges of solar energy. Solar Energy Conversion Technologies: Overview of solar thermal and solar photovoltaic technologies, Brief comparison of various solar energy conversion methods.

Unit II **15 Hrs**

Basics of Photovoltaic Technology: Photoelectric effect, Photoconductivity, Photo emissive effect and photovoltaic effect, A comparison, Working principle of solar cells, Generation of charge carriers, Separation and collection solar cell parameters, Equivalent circuit, External solar cell parameters, External quantum efficiency and Equivalent circuit.

Losses and Efficiency Limits: The thermodynamic limit, The Shockley-Queisser Limit, Spectral mismatch**,** Other Losses (Optical losses, Solar cell collection losses, Additional limiting factors), Design Rules for

Solar Cells.

Unit III **15 Hrs**

Solar Cell Technologies: Silicon wafer based solar cell, basic silicon solar cell, Strategies to enhance Absorption, reduce surface recombination, reduce series resistance, thin film solar cells, Transparent conducting oxides, Chalcogenide solar cells, Organic photovoltaics, Perovskite, Dye sensitized solar cells, Hybrid organic, Inorganic solar cells, multi-junction solar cells, Spectral conversion, Multi exciton generation, Photovoltaic system Design.

Unit IV **15 Hrs**

Manufacture of Solar Cells and Panels: Single-Crystal and Polycrystalline Cells, Amorphous Silicon and Thin-Film Fabrication.
PV Systems: Types of PV systems, Components of a PV system, PV System Economics and Ecology, Maximum Power Point Tracking, Estimation of Loads and Load Profiles, Estimation of Available Solar Radiation, PV System Sizing. Photovoltaic Applications.

Text Books and Reference Books:

1. G.D. Rai, “Solar Energy Utilization”, Khanna Publishers 1995.

2. H.P. Garg and Satya Prakash, “Solar Energy Fundamentals and Applications”, Tata McGraw Hill 1977.
3. M. P. Agarwal, “Solar Energy”, S. Chand and Co. Ltd.
4. Arno H.M. Smets, Klaus Jäger, Olindo Isabella, René ACMM van Swaaij, Miro Zeman, “Solar Energy - The physics and Engineering of Photovoltaic Conversion, Technologies and Systems”, UIT Cambridge, England.
5. D. Yogi Goswami, “Principles of Solar Engineering”, CRC Press, Taylor & Francis Group 2015.
6. Chetan Singh Solanki, “Solar Photovoltaics, Fundamentals, Technologies and Applications”, PHI Learning 2011.

M.Sc. Semester IV (Major Elective-4) Paper III (04MSCPH 3.4) Material Synthesis and Characterization

Credit 04 Theory 60 Hrs

Course Objectives:

- To provide knowledge of conceptual materials synthesis and characterization.
- To familiar with different types of materials and their structures.

Course Outcomes:

After completion of this course, students will be able to

- To elucidate the important features of Materials, synthesis and its characterization by covering structure.
- To have the knowledge of synthesis of nanomaterials, Physical properties and Characterization of nanomaterials.

Unit I 15 Hrs

Structure: Crystalline structure of materials, unit cells and space lattices, x-ray diffraction of crystal structures, miller indices of planes and directions, packing geometry in metallic, covalent and ionic solids. Concept of amorphous, single and polycrystalline materials. Crystal growth techniques. Imperfections in crystalline solids. Semiconductors: General properties and band structure, carrier statistics, impurities, intrinsic and extrinsic semiconductors, drift and diffusion currents, mobility, Hall effect.

Unit II 15 Hrs

Advanced Materials : Smart materials, exhibiting ferroelectric, piezoelectric, optoelectric, semiconducting behavior, lasers and optical fibers, photoconductivity and superconductivity, nanomaterials – biomaterials, superalloys, shape memory alloys.

Basics of biomaterials: Concept of biocompatibility, responsiveness, degradation, estimations of degradation and biocompatibility, technically important form of polymers: Hydrogel, bioceramics, bioelastomers, and membrane.

Unit III **15 Hrs**

Nano-materials and Tools: Introduction – nanostructural materials – metals, semiconductors and ceramics. Synthesis of nanoparticles– sol-gel method, combustion synthesis method, laser pyrolysis –sputtering techniques, plasma techniques. Various chemical methods of synthesis, Unique properties of nanomaterials. Metal nanoparticles – electronic and optical properties, Functionalized metal nanoparticles- synthesis, characterization, organization and applications –- Semiconductor nanoparticles - synthesis, characterization and applications of quantum dots – Optical spectroscopy, Electron Microscopy, Atomic Force Microscopy, X-Ray diffraction of nanoscale materials.

Unit IV **15 Hrs**

Physical properties and Characterization - free volume, viscosity, Mechanical properties- Tensile testing-stress-strain plots of different types of materials, viscoelastic behavior, rubber-like elasticity, factors influencing the strength of material. Electrical properties- Dielectric relaxation, theory & mechanism of electrical conduction, semiconducting & conducting materials, applications. Optical properties- refractive index, birefringence, UV, ESR, Raman, NMR, IR spectroscopy, luminescence properties. Applications of optical microscope, SEM, TEM, XRD. FTIR, and PL characteristics.

Thermal properties - Heat capacity of amorphous & crystalline polymers, glass transition, polymer degradation. Thermal analysis – DSC, TMA, TG.

Text Books and Reference Books:

1. C. Kittel, "Introduction to Solid State Physics", 8th Ed., Wiley, 2012
2. James F. Shackelford, "Materials Science And engineering Handbook", Third Edition CRC Press, New York, (2010).
3. Eric J. Mittemeijer, "Fundamentals of Materials Science: The Microstructure–Property Relationship Using Metals as Model Systems", Springer 2011.
4. Ashutosh Tiwari and Atul Tiwari, "Nanomaterials in drug delivry, Imaging and Tissue Engineering", Wiley (2013).
5. Srikanth Pilla, "Handbook of Bioplastics and Biocomposites Engineering Applications", Wiley (2011).

6. Susheel Kalia and Luc Averous , "Biopolymers: Biomedical and Environmental Applications", Wiley 2011.
7. M. W. Barsoum, "Fundamentals of Ceramics", McGraw Hill, 1997.
8. L. M. Liz-Marzan and P V Kamat, "Nanoscale Materials", Kluwer 2003
9. H. S. Nalwa, "Nanostructured Materials and Nanotechnology", Academic Press 1999.
10. John C. Berg, "An Introduction to Interfaces and Colloids: The bridge to Nanoscience", World Scientific Publishing Co. Pvt. Ltd, 2009
11. Inzelt Gyorgy, "Conducting polymers: A New Era in Electrochemistry", Springer, 2008
12. K.N. Shinde, S. J. Dhoble, H.C. Swart and K. Park , "Phosphate Phosphors for Solid State Lighting", Springer.
13. C. P. Poole and Frank J. Owens, "Introduction to Nanotechnology", Wiley 2006
14. H. R. Chen, "Shape Memory Alloys: Manufacture, Properties and Applications", Nova Science 2010.
15. Raymond B Seymour & Charles E Carraher Jr, "Polymer Chemistry - An introduction",Marcel Dekker 1996.
16. M. Mishra, "Polymer Chemistry", Wiley Eastern 1993.
17. A. Tager, "Physical Chemistry of Polymers", Mir Pub., 1978.
18. I. I. Perepechko, "An Introduction to Polymer Physics", Mir Pub. 1983.
19. D. G. Hundiwale, "Experiments in Polymer Science", New Age International Publishers 2009.
20. Arun Kumar Singh, "Applied Polymer Science", Anmol 2012
21. P. Bahadur, N. V. Sastry, "Principles of Polymer Science", Narosa 2005.
22. Willard, Merritt, Dean, Settle, "Instrumental Method of Analysis", Wadsworth Publishing Company 1988.
23. Skoog, Holler, Crouch, "Principle of Instrumental Analysis", Harcourt College Pub 1997.
24. V. Shah, "Handbook of Plastic Testing, Technology", Wiley-Interscience 2007.
25. T. Tanaka, "Experimental Methods in Polymer Sciences", Academic Press 1999.
26. Robert M. Silverstein, "Spectrometric Identification of Organic Compounds", Wiley 1991.
27. Roger S. Macomber, "A complete introduction to NMR spectroscopy", Wiley-Interscience 2008.
28. Vijay B. Pawade, Ritesh L. Kohale, Sanjay J. Dhoble, Hendrik C. Swart, "Phosphor Handbook: Process, Properties and Applications", Elsevier.

M.Sc. Semester IV (Major Elective-5) Paper III (04MSCPH 3.5) X-ray Emission and Absorption Spectroscopy

Credit 04 Theory 60 Hrs

Course Objectives:

- To understand X-ray absorption and emission methods in both the hard and soft X-ray domain, with an emphasis on their applications in Physics, material science, and Nanoscience.
- To provide an overview on the potential of X-ray spectroscopy to characterize molecular species and materials together with the theoretical basis and the experimental know-how required to successfully apply such methods to multi-disciplinary research problems.

Course Outcomes:

After completion of this course, students will be able to

- Apply and interpret X-ray absorption and emission spectroscopy to determine structural and electronic properties of molecular species and materials.
- To understand the basic notions of radiation-matter interaction and their implementation in photon-in spectroscopy.
- Have the Critical understanding of the differences and complementarities between hard and soft X-ray spectroscopy

Unit I 15 Hrs

X-ray emission from thick and thin targets. High tension and vacuum techniques. Synchrotron radiation: Production and properties of radiation from storage rings, Insertion devices. Pelletron as source of X-rays. Absorption of X-rays and X-ray Fluorescence Physics process of X-ray absorption. Measurement of X-ray absorption coefficients.

Unit II 15 Hrs

X-ray Spectroscopy: Experimental techniques of wavelength and energy dispersive x-ray spectroscopy. Bragg and double crystal spectrographs. Focusing spectrographs. Tangential incidence grating spectrographs. Methods of detection and measurement, resolving power of detectors. X –ray emission and absorption spectra. Energy level diagram. Dipole and forbidden lines, Satellite lines and their origin, Regular and irregular doublets. Relative intensities of X-ray lines.

Unit III 15 Hrs

Chemical Effects in X-ray Spectra: Chemical effects in X-ray spectra. Fine structures (XANES and EXAFS) associated with the absorption edges and their applications. X-ray spectroscopy with synchrotron sources. Soft

X-ray spectroscopy of the solid state. X-ray fluorescence. Photoelectron spectroscopy, Auger effect. Fluorescence yield. X-ray fluorescence analysis and its applications.

Unit IV **15 Hrs**

Scattering and Dispersion of X-rays: Scattering of X-rays. Thomson scattering. Polarization of X-rays. Compton scattering. Wave mechanical treatment of scattering. Scattering by a pair of electrons. Scattering by a helium atom. Scattering by many electrons. Raman's theory of X-ray scattering. Experiments on scattering by monatomic and polyatomic gases, liquids and amorphous solids. Dispersion theory applied to X-rays. Calculation of the dielectric constant. Refraction of X-rays. Methods for measurement of refractive index. X-ray optics and X-ray microscopy.

Text Books and Reference Books:

1. H. Compton and S. K. Allison, "X-rays in theory and Experiment", D. Van Nostrand Co.
2. G. L. Clark, "Applied X-rays", Mc Graw Hill Book Company.
3. J. A. Nielsen and D. Mc. Morrow, "Elements of Modern X-ray Physics", Wiley.
4. A. G. Michette and C. J. Buckley, "X-ray Science and Technology", Institute of Physics Publications.
5. M. A. Blokhin, " X-ray Spectroscopy", Wiley.
6. B. K. Agarwal, "X-ray Spectroscopy", Springer.
7. E. P. Bertin, "Principles and Practice of X-ray Spectrometric Analysis", Springer.
8. L. V. Azaroff, "X-ray Spectroscopy", .
9. C. Bonnelle and C. Mande, "Advances in X-ray Spectroscopy", Pergamon Press.
10. D. C. Koningsberger and R. Prins, "X-ray Absorption Principles, Applications, Techniques of EXAFS, SEXAFS and XANES", Wiley.
11. N.F.M. Henry, H. Lipson and W. A. Wooster, "The interpretation of X-ray Diffraction Photographs", Macmillan and Company.
12. K. Lonsdale, "Crystals and X-rays", G. Bell.
13. B. D. Cullity,S. R. Stock, "Elements of X-ray Diffraction", Pearson.