GOVERNMENT ARTS COLLEGE (AUTONOMOUS)
COIMBATORE-641 018

Learning Outcomes-based Curriculum Framework (LOCF) for

M.Sc. PHYSICS
(Effective from the Academic year 2021-2022)

POSTGRADUATE AND RESEARCH DEPARTMENT OF PHYSICS

MAY-2021

Preamble

The world has advanced considerably throughout the decades and the need for higher education has been on the rise. The role of higher education in social and spatial mobility has attracted considerable attention. It provides opportunities for lifelong learning, allowing people to upgrade their knowledge and skills from time to time based in societal needs.

Over the past decades the higher education system of our country has undergone substantial structural and functional changes resulting in both quantitative and qualitative development of the beneficiaries. Such changes have gained momentum with the introduction of Choice Based Credit System (CBCS) which further expects learning outcome-based curriculum in order to maximize the benefits of the newly designed curriculum. The learning outcome-based curriculum will definitely help the teachers of the discipline to visualize the curriculum more specifically in terms of the learning outcomes expected from the students at the end of the instructional process. It is pertinent to mention here that the purpose of education is to develop an integrated personality of the individual and the educational system provides all knowledge and skills to the learner for this.

Tamil Nadu State Council for Higher Education (TANSCHE) has formed the State Integrated Boards of Studies, which, with great diligence and expertise has devised the mandatory areas that have to be covered for three-year undergraduation and two-year postgraduation courses to realize the facilitation of the mobility of faculty and students from one university to another and to easily solve the problem of equivalence among courses. Great care has been taken so that these areas would take 75% of the course content and the remaining 25% can be decided by the individual institutions. The areas that must be covered by the student that are mandatory for earning the degree to have due value has been worked out so that the student will gain enough depth of knowledge in the subject concerned. 25% percent of the syllabus should be designed by the institutions, and the areas covered under this also must have a weightage of 25%. This gives the autonomous institution seamless liberty on every Board of Studies (BOS) to innovate and experiment, and more importantly, it is here that the institution devises appropriate strategies by which (i) to make creative and critical applications of what has been learnt in the mandatory components, and (ii) to meaningfully connect the learners to the career demands and expectations. It is essential that the theoretical subject knowledge of the students must be translated in to practical hands-on experience.

One of the significant reforms in the undergraduate education is to introduce the Learning Outcomes-based Curriculum Framework (LOCF) which makes it student-centric, interactive and outcome-oriented with well-defined aims, objectives and goals to achieve. LOCF also aims at ensuring uniform education standard and content delivery across the country which will help the students to ensure similar quality of education irrespective of the institute and location. With initiatives of University Grants Commission (UGC) for nation-wide adoption and implementation of the LOCF for bachelor's programmes in colleges, universities and HEIs in general. A Core Expert Committee (CEC) was constituted to formulate the modalities for developing the LOCF in various subjects being taught in the undergraduate courses in sciences, humanities, commerce and professional courses. The CEC also constituted the Subject Expert Committees (SEC) in various subjects to prepare detailed guidelines for the LOCF in subjects concerned.

The key components of the planning and development of LOCF are given in terms of clear and unambiguous description of the Graduate Attributes (GA), Qualification Descriptors (QD), Program Learning Outcomes (PLO) and Course Learning Outcomes (CLO) to be achieved at the end of the successful completion of each undergraduate program to be offered by HEIs. In undergraduate education in Information Technology, the programme of study leading to the degree of B.Sc. in Information Technology is discussed herewith.

The Qualification Descriptors (QD), Program Learning Outcomes (PLO) and the Course Learning Outcomes (CLO) were also finalized keeping the broad requirement of the programme in view. The LOCF also gives general guidelines for the Teaching Learning Process (TLP) corresponding to each component of theory, experiment, tutorials, projects and industrial / field visits to be followed in order to achieve the stated outcomes for each component. Finally, some suggestions for using various methods in the assessment and evaluation of learning levels of students are also made. It is a student centric framework where they are expected to learn fundamentals of Information Technology along with the latest trends and techniques like Artificial Intelligence, Internet of Things, Machine Intelligence along with advanced skillsets that include Mobile Application Development, Object Oriented Programming among many other courses.

1. Introduction

Outcome based education empowers students to choose their desired subject. Focusing on results outcome-based education (OBE) generates a transparent expectation of the top results. Teachers can structure their classes according to the student's wishes by reading transparently what needs to be done.

The learning outcome-based curriculum framework in Physics should also allow for the flexibility and innovation in the program design of the UG education, and its syllabi development, teaching learning process and the assessment procedures of the learning outcomes. The process of learningis defined by the following steps which should form the basis of final assessment of the achievement at the end of the program.

- The accumulation of facts of nature and the ability to link the facts to observe and discover the laws of nature i.e., develop an understanding and knowledge of the Physics.
- The ability to use this knowledge to analyze new situations and learn skills and tools like mathematics, engineering and technology to find the solution, interpret the results and make predictions for the future developments.
- The ability to synthesize the acquired knowledge, understanding and experience for a better and improved comprehension of the physical problems in nature and to create new skills and tools for their possible solutions.

The conceptualization and formulation of the learning outcomes for an postgraduate program in Physics is aimed to achieve (i) and (ii) above while the (iii) could be planned for research programs in Physics in the Higher Education Institutions in India.

1.1 Types of courses and Course structure

Each program may have three types of courses namely Core courses, Elective courses and Self-study/Skill-based courses.

1.1.1 Core Courses

The Core courses are those courses whose knowledge is deemed essential for the students registered for a particular Master's degree program. Where feasible and necessary two or more programs may prescribe one or more common core courses.

- The core courses shall be mandatory for all the students registered for the master's degree program.

- The core courses shall be spread all the semesters of the program.

1.2.1 Elective courses

The elective courses can be chosen from a pool of papers. These courses are intended to

- allow the student to specialise in one or more branches of the broad subject area;
- help the student to acquire knowledge and skills in a related area that may have applications in the broad subject area;
- help the student to bridge any gap in the curriculum and enable acquisition of essential skills, for example, statistical, computational, language, communication skills etc.
- help the student to pursue area of interest
- The student may also choose additional elective courses offered by the college to enable him /her to acquire extra credits from the discipline or across the discipline

1.3.1 Project work

A course (core/elective/self-study/skill based) may take the form of a project work.

2. Learning Outcomes based approach to Curriculum planning

2.1 Nature and extent of Postgraduate Program in Physics:

The PG programs in Physics builds on the UG Physics taught at the Colleges in the country. The curricula and syllabi should be framed and implemented in such a way that the basic connection between theory and experiment and its importance in understanding Physics should be apparent to the student. This is very critical in developing a scientific temperament and urge to innovate, create and discover in Physics. The Postgraduate program in Physics is presently being offered though the course designed for granting the following degree by various colleges and universities in India. The course is of TWO YEAR duration spread over FOUR semesters after the DEGREE level Physics course:

2.2 Aims of Postgraduate program in Physics

The aims and objectives of our PG educational programs in sciences in general and Physics in particular should be structured to

a) create the facilities and environment in all the educational institutions to consolidate the knowledge acquired at Undergraduate level and to motivate and inspire the students to create deep interest in Physics, to develop broad and balanced knowledge and understanding of physical concepts, principles and theories of Physics.

b) learn, design and perform experiments in the laboratories to demonstrate the concepts, principles and theories learned in the classrooms.

c) develop the ability to apply the knowledge acquired in the classroom and laboratories to specific problems in theoretical and experimental Physics.

d) expose the student to the vast scope of Physics as a theoretical and experimental science with applications in solving most of the problems in nature spanning from 10^{-15} m to 10^{26} m in space and 10^{-10} eV to 10^{25} eV in energy dimensions.

e) emphasize the discipline of Physics to be the most important branch of science for pursuing the interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary andmultidisciplinary areas.

f) emphasize the importance of Physics as the most important discipline for sustaining the existing industries and establishing new ones to create job opportunities at all levels of employment.

In view of opening the new windows in higher education and research and opening job opportunities at all levels from technicians to innovator scientists and engineers, one undergraduate program is offered in our institution.

3. Postgraduate Attributes in Physics

Some of the characteristic attributes of a graduate in Physics are

3.1 Education and Training

a. Provide training of the highest academic quality in Physics in a challenging and supportive learning environment.
b. Develop a systematic understanding of both core areas and advanced topics in the study of Physics
c. Develop the ability to evaluate primary evidence critically; and the conceptual understanding to present arguments and solutions based on theory and research analyses
d. Promote an appreciation of the limits to our present understanding of the subject, its applications in various fields.
e. Provide for student interaction with high-level scientific expertise and advanced equipment in an environment committed to scientific advance.

f. Develop skills in gathering and interpreting the research results used to gain this understanding and thereby equip students with the foundations for their professional careers or additional study.

3.2 Communication Skills

a. Skills to communicate in written, numerical, graphical and verbal forms, in ways that are appropriate to different audiences and indifferent situations, ranging from scientific and industry reports, to group and individual oral presentations, and from blogs and outreach articles, to news articles and essays.
b. Formulate a coherent written, electronic or oral presentation on the basis of material gathered (e.g. textual, numerical, verbal, graphical) and organised independently on a given topic.
c. Express clearly ideas and arguments, both orally and in writing and in electronic media.
d. Use group discussions and joint seminar presentations to research and present work collaboratively; and Develop oral presentation and participation skills during seminars and group-work, and in written form through online e- learning tools, dissertations and essays.

3.3 Critical Thinking

a. Acquire an understanding of the concept in physics and related disciplines and an ability to understand, integrate, and extend it so that all fundamental geological concepts are accessible.
b. Acquire, digest and critically evaluate scholarly arguments, the assumptions behind them, and their theoretical and empirical components.

3.4 Problem Solving

a. Skills to recognise and articulate a problem and then apply appropriate conceptual frameworks and methods to solve it.
b. Emphasis is placed on larger, integrated problem-solving exercises, during which students are taught how to process complex data sets using a diverse range of skills and knowledge. This provides the foundation for student-led independent, but academically directed, project work.

3.5 Analytical Reasoning

a. A broad knowledge base in physics and related disciplines and an ability to understand, integrate, and extend it so that all fundamental physical concepts are accessible.
b. Competency in both theory and laboratory skills, and in data analysis, interpretation and presentation that permit the successful pursuit of pure or applied problems in Physics.

3.6 Research-Related Skills

a. Develop a research design, which has an appropriate problem related to physics but may incorporate some scientific methods, ability to plan and write a research paper.

b. Ability to process and interpret large, complex, datasets, to hypothesis set and test, and to function as a numerate, literate scientist able to prove insight and guidance related to real-world problems and issues.
c. Ability to apply knowledge and understanding to address familiar, unresolved and more open-ended problems.
d. Ability to collect, analyse, synthesise, summarise and inter-relate diverse processes and facts, to formulate and test hypotheses and reach conclusions.

3.7 Self and Time Management

a. Time management skills are developed through interaction with the assessment process in all years: students must learn how to meet deadlines for submission of continuous assessment material and how to set aside appropriate time to prepare for end of year examinations.
b. Time management is integral to the student's independent mapping project.

3.8 Team Work

a. Ability to contribute effectively to team objectives and interact productively with others both in project-related settings and in meetings.
b. This is addressed through group exercises in all years of the Physics programme, including in-class presentations, group lab-sessions where students use research equipment, mock-industry presentations to panels of outside industry experts, and group fieldwork mini-projects.

3.9 Scientific Reasoning

a. View the Physics from new and challenging perspectives of time, space, process and pattern.
b. Develop a systematic understanding of both core areas and advanced topics in the study of Physics
c. Provide for student interaction with high-level scientific expertise and advanced equipment in an environment committed to scientific advance.
d. Develop the ability to evaluate primary evidence critically; and the conceptual understanding to present arguments and solutions based on primary data and theory.

3.10 Digital Literacy

a. ability of advanced Word skills, databases and spreadsheets
b. ability to use digital resources for presentations

3.11 Moral and Ethical Values

a. The degree to which every student engages with these themes will vary but it is important that all think especially about ethical issues
b. Avoid unethical behaviour such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights, and adopting objectives, unbiased and truthful actions in all aspects of work.

3.12 Leadership Readiness

a. Provide training of the highest academic quality in Physical sciences in a challenging and supportive learning environment
b. Be accessible to those qualified at intake in a broad and diverse range of sciences.
c. Provide an excellent preparation for a career in professional practice in Material Sciences, and specialist areas of physics

3.13 Life-long Learning

a. ability to blend academic and practical skills
b. ability to transfer such skills to other domains of one's life and work

3.14 Global Competency

a. After completing course in Physics, the student is expected to be fully knowledgeable about the subject and not only from the point of view of examination.
b. He/She will be ready to accept challenges and stand in competition at a national and global level.

4. Qualification descriptors for a PG program in Physics

4.1 Qualification descriptors for a M.Sc. Physics

The qualification descriptors for a M.Sc. Physics program may include the following. The graduates should be able to:

- Demonstrate

  (i) a fundamental/systematic or coherent understanding of the academic field of Physics, its different learning areas like Astrophysics, Material science, Nuclear and Particle Physics,Condensed matter Physics, Atomic and Molecular Physics, Mathematical Physics, Analytical dynamics, Space science and applications, and its linkages with related disciplinary areas/subjects like Chemistry, Mathematics, Life sciences, Environmental sciences, Atmospheric Physics, Computer science, Information Technology;

  (ii) procedural knowledge that creates different types of professionals related to different areas of study in Physics outlined above, including research and development, teaching and government and public service;

  (iii) skills in areas related to specialization area relating the subfields and current developmentsin the academic field of Physics.

- Use knowledge, understanding and skills required for identifying problems and issues relating to Physics, collection of relevant quantitative and/or qualitative data drawing on a wide rangeof sources from various Physics laboratories of the world, and their application, analysis and evaluation using methodologies as appropriate to Physics for formulating new theories and concepts.

- Communicate the results of studies undertaken accurately in a range of different contexts using the main concepts, constructs and techniques of Physics. Develop communication abilities to present these results in technical as well as popular science meetings organized in various universities and other private organizations.
- Ability to meet one's own learning needs, drawing on a range of current research and development work and professional materials, and interaction with other physicists around the world.
- Apply one's knowledge of Physics and theoretical and laboratory skills to new/unfamiliar contexts to identify and analyse problems and issues and solve complex problems in Physics and related areas with well-defined solutions.
- Demonstrate Physics-related technological skills that are relevant to Physics-related job trades and employment opportunities.

5. Programme Learning Outcomes relating to M.Sc. Physics

5.1 Program Learning Outcomes in M.Sc. Physics

The student graduating with the Degree B.Sc. Physics should be able to

- Acquire

  i) a fundamental/systematic or coherent understanding of the academic field of Physics, its different learning areas and applications in basic Physics like Astrophysics, Material science, Nuclear and Particle Physics, Condensed matter Physics, Atomic and Molecular Physics, Mathematical Physics, Analytical dynamics, Space science, and its linkages with related disciplinary areas / subjects like Chemistry, Mathematics, Life sciences, Environmental sciences, Atmospheric Physics, Computer science, Information Technology;

  ii) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Physics, including professionals engaged in research and development, teaching and government/public service;

  iii) skills in areas related to one's specialization area within the disciplinary/subject area of

Physics and current and emerging developments in the field of Physics.

- Demonstrate the ability to use skills in Physics and its related areas of technology for formulating and tackling Physics-related problems and identifying and applying appropriate physical principles and methodologies to solve a wide range of problems associated with Physics.
- Recognize the importance of mathematical modeling simulation and computing, and the role ofapproximation and mathematical approaches to describing the physical world.
- Plan and execute Physics-related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevanttheories of Physics.
- Demonstrate relevant generic skills and global competencies such as (i) problem-solving skills that are required to solve different types of Physics-related problems with well-defined solutions, and tackle open-ended problems that belong to the disciplinary-area boundaries; (ii) investigative skills, including skills of independent investigation of Physics-related issues and problems; (iii) communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature; (iv) analytical skills involving payingattention to detail and ability to construct logical arguments using correct technical language related to Physics and ability to translate them with popular language when needed; (v) ICT skills; (vi) personal skills such as the ability to work both independently and in a group.
- Demonstrate professional behavior such as (i) being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behavior such as fabricating, falsifying or misrepresenting data or committing plagiarism; (ii)the ability to identify the potential ethical issues in work-related situations; (iii) appreciation of intellectual property, environmental and sustainability issues; and (iv) promoting safe learning and working environment issues in work related situations; (iii) appreciation of intellectual property, environmental and sustainability issues; and (iv) promoting safe learning and working environment.

PROGRAM LEVEL OUTCOMES OF M.Sc. PHYSICS

A postgraduate student of the program of study in Physics should be able to

PLO-1 Demonstrate

(i) a systematic, extensive and coherent knowledge and understanding of the academic field of Physics, as a whole and its applications and links with related disciplinary areas/subjects; including a critical understanding of the established theories, principles and concepts, and of a number of advanced and emerging issues in the field of study; [Guiding attribute: **Disciplinary (subject) knowledge**]

(ii) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Physics, including professionals engaged in research and development, teaching and government and public service; [Guiding attribute: **Communication skills**]

(iii) Skills in areas related to one's specialization, critical understanding of the current developments in the area physics and current and an ability to use established techniques of analysis and enquiry within the area of specialization.[Guiding attribute: **Critical thinking**]

PLO-2 Demonstrate comprehensive knowledge about materials, including current research, scholarly, and/or professional literature, relating to essential and advanced learning areas pertaining to the chosen disciplinary areas, and techniques and skills required for identifying problems and issues relating to the disciplinary area and field of study.
[Guiding attribute: **Research – related skills**]

PLO-3 Demonstrate skills in identifying information needs, collection of data, analysis and interpretation of data using appropriate methodologies for formulating evidence based solutions and arguments.[Guiding attribute: **Analytical reasoning**]

PLO-4 Use knowledge, understanding and skills for critical assessment of a wide range of ideas and complex problems and issues relating to the field of Physics.[Guiding attribute: **Lifelong learning**]

PLO-5 Communicate the results of studies undertaken in an academic field of study accurately in a range of different contexts using the main concepts, constructs and techniques of the subject(s) of study.[Guiding attribute: **Scientific reasoning**]

PLO-6 Address one's own learning needs relating to current and emerging areas of study, making use of research, development and professional materials as appropriate, including those related to new frontiers of knowledge.[Guiding attribute: **Self – directed learning**]

PLO-7 Apply one's disciplinary knowledge and transferable skills to new/unfamiliar contexts and to identify and analyze problems and issues and seek solutions to real-life problems.[Guiding attribute: **Problem solving**]

PLO-8 Demonstrate subject-related and transferable skills that are relevant to some of the job trades and employment opportunities.

i. Ability to work effectively and respectfully with diverse teams; facilitate cooperative or coordinated effort on the part of a group, and act together as a group or a team in the interests of a common cause and work efficiently as a member of a team; [Guiding attribute: **Cooperation / Team work**]

ii. Capability for mapping out the tasks of a team or an organization, and setting direction, formulating an inspiring vision, building a team who can help achieve the vision, motivating and inspiring team members to engage with that vision, and using management skills to guide people to the right destination, in a smooth and efficient way; [Guiding attribute: **Leadership readiness / quality**]

iii. Capability to use ICT in a variety of learning situations, demonstrate ability to access, evaluate, and use a variety of relevant information sources; and use appropriate software for analysis of data; [Guiding attribute: **Information / Digital Literacy**]

iv. Ability to embrace moral/ethical values in conducting one's life, formulate a position/argument about an ethical issue from multiple perspectives, and use ethical practices in all work. Capable of demonstrating the ability to identify ethical issues related to one's work, avoid unethical behaviour such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights; appreciating environmental and sustainability issues; and adopting objective, unbiased and truthful actions in all aspects of work; [Guiding attribute: **Moral and ethical awareness / reasoning**]

v. Possess knowledge of the values and beliefs of multiple cultures and a global perspective; and capability to effectively engage in a multicultural society and interact respectfully with diverse groups; [Guiding attribute: **Multicultural competence**]

6. M.Sc. PHYSICS COURSE STRUCTURE

M.Sc. PHYSICS CURRICULUM FOR THE STUDENTS ADMITTED FROM 2021-2022 ONWARDS

UNDER LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK (LOCF)

SEMESTER – I

S. No.	Subject Code	Part	Title of the Paper	Credit	Maximum Marks			Exam Duration	Hrs/ Week	Passing Minimum	
					Internal	External	Total			External	Total
1.	21MPH11C	A	Paper I: Classical and Statistical Mechanics	4	50	50	100	3 Hrs	5	25	50
2.	21MPH12C	A	Paper II: Quantum Mechanics – I	4	50	50	100	3 Hrs	5	25	50
3.	21MPH13C	A	Paper III: Mathematical Physics	5	50	50	100	3 Hrs	5	25	50
4.	21MPH14E	B	Elective I: Problems in Physics – I	3	50	50	100	3 Hrs	3	25	50
	TOTAL			**16**			**400**		**18**		
5.	21MPH25P	A	Practical I: General Experiments	Examination at the end of Second Semester					6		
6.	21MPH26P	A	Practical II: General Electronics	Examination at the end of Second Semester					6		

SEMESTER – II

S. No.	Subject Code	Part	Title of the Paper	Credit	Maximum Marks			Exam Duration	Hrs/ Week	Passing Minimum	
					Internal	External	Total			External	Total
1.	21MPH21C	A	Paper IV: Quantum Mechanics - II	4	50	50	100	3 Hrs	5	25	50
2.	21MPH22C	A	Paper V: Computational Physics	4	50	50	100	3 Hrs	5	25	50
3.	21MPH23C	A	Paper VI: Electromagnetic Theory	5	50	50	100	3 Hrs	5	25	50
4.	21MPH24E	B	Elective II: Problems in Physics –II	3	50	50	100	3 Hrs	3	25	50
5.	21MPH25P	A	Practical I: General Experiments	3	50	50	100	4 Hrs	6	25	50
6.	21MPH26P	A	Practical II: General Electronics	3	50	50	100	4 Hrs	6	25	50
	TOTAL			**22**			**600**		**30**		

SEMESTER – III

S. No.	Subject Code	Part	Title of the Paper	Credit	Maximum Marks			Exam Duration	Hrs/ Week	Passing Minimum	
					Internal	External	Total			External	Total
1.	21MPH31C	A	Paper VII: Molecular Spectroscopy	4	50	50	100	3 Hrs	5	25	50
2.	21MPH32C	A	Paper VIII: Nuclear Physics	4	50	50	100	3 Hrs	5	25	50
3.	21MPH33C	A	Paper IX: Advanced Electronics and Microprocessor	4	50	50	100	3 Hrs	5	25	50
4.	21MPH34E	B	Elective III: Problems in Physics – III	3	50	50	100	3 Hrs	3	25	50
	TOTAL			**15**			**400**		**18**		
5.	21MPH45P	A	Practical III: Advanced Experiments	Examination at the end of Fourth Semester					5		
6.	21MPH46P	A	Practical IV: Microprocessor and Special Electronics	Examination at the end of Fourth Semester					5		
7.	21MPH47V	A	Project and Viva-voce	Examination at the end of Fourth Semester					2		

SEMESTER – IV

S. No.	Subject Code	Part	Title of the Paper	Credit	Maximum Marks			Exam Duration	Hrs/ Week	Passing Minimum	
					Internal	External	Total			External	Total
1.	21MPH41C	A	Paper X: Material Science	4	50	50	100	3 Hrs	5	25	50
2.	21MPH42C	A	Paper XI: Optical and Thin Film Physics	4	50	50	100	3 Hrs	5	25	50
3.	21MPH43C	A	Paper XII: Condensed Matter Physics	5	50	50	100	3 Hrs	5	25	50
4.	21MPH44E	B	Elective IV: Problems in Physics – IV	3	50	50	100	3 Hrs	3	25	50
5.	21MPH45P	A	Practical III: Advanced Experiments	3	50	50	100	4 Hrs	5	25	50
6.	21MPH46P	A	Practical IV: Electronics, Microprocessor and C++ Programming	3	50	50	100	4 Hrs	5	25	50
7.	21MPH47V	A	Project and Viva-voce	15	50	50	100	--	2	25	50
	TOTAL			**37**			**700**		**30**		

Subject	Part	No. of Papers	Credit/Paper	Total Credit	Total Marks
Core Papers	A	9	4	36	900
Core Papers	A	3	5	15	300
Practical Papers	A	4	3	12	400
Project and Viva-voce	A	1	15	15	100
Elective – Theory	B	4	3	12	400
Total		**21**		**90**	**2100**

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	**Core 1: Classical and Statistical Mechanics**	**I**	**21MPH11C**	**5**

COURSE LEVEL OUTCOMES:

On the successful completion of the course, students will be able to

CLO-1 Explain the mechanics of a system of particles, analyze small oscillations and elucidate the Lagrangian and Hamiltonian approaches in classical mechanics.
CLO-2 Identify Hamilton-Jacobi theory and distinguish time dependent and time independent HJ equations.
CLO-3 Use HJ and AAV methods to solve harmonic oscillator problem and develop equations of motion for various systems with small oscillations.
CLO-4 Analyze the kinematics and kinetics of a rigid body.
CLO-5 Discuss about classical and quantum statistics.
CLO-6 Evaluate Most probable speed, Mean speed, Mean square speed and Root mean square speed.
CLO-7 Apply quantum statistics to Ideal BE and FD gases.

UNIT I:
Mechanics of a System of Particles and Lagrangian Formulation: Mechanics of a system of particles – Conservation of linear momentum - Conservation theorem for angular momentum – Conservation of energy – Hamilton's variational principle - Deduction of Lagrange's equations of motion from Hamilton's principle.
Hamiltonian Formulation of Mechanics: Hamiltonian – Hamilton's canonical equations of motion – Advantage of Hamiltonian approach – Concept of Principle of least action – Canonical transformations – Generating function – Condition for a transformation to be canonical.

UNIT II:
Hamilton-Jacobi Theory: Hamilton-Jacobi method – Hamilton-Jacobi equation for Hamilton's characteristic function - Solution of harmonic oscillator problem by HJ method – Action and angle variables – Solution of harmonic oscillator problem by AAV method – Poisson's and Lagrange's brackets.
Mechanics of Small Oscillations: Stable and unstable equilibrium – Lagrange's equations of motion for small oscillations – Normal co-ordinates and normal frequencies of vibration – The Parallel pendula – Double pendulum – Linear triatomic molecule.

UNIT III: Rigid Body Dynamics: Generalised co-ordinates for rigid body motion – Euler's theorem – Chasles' theorem – Euler's angles – Angular momentum of rigid body: Angular velocity, Angular momentum and Moments and products of inertia – Principal axes transformation – Equations of motion of a rigid body: Euler's equations – The motion of a symmetric top under the action of gravity.

UNIT IV: Classical Statistics:
Maxwell-Boltzmann distribution law – Maxwell's law of distribution of velocities – Principle of equipartition of energy – Derivation of mean energy of harmonic oscillator –

Mean values obtained from distribution law: Most probable speed, Mean speed, Mean square speed and Root mean square speed – Microcanonical ensemble – Relation of entropy of a system in statistical equilibrium with thermodynamic quantities – Gibbs canonical ensemble – Grand canonical ensemble.

UNIT V: Quantum Statistics:
Bose-Einstein statistics – conditions of Bose-Einstein statistics – Fermi-Dirac statistics - Ideal BE gas: Gas degeneracy and Bose-Einstein condensation – Black body radiation and the Planck's radiation law - Ideal FD gas: Electron gas, Free electron model and electronic emission – Richardson-Dushman equation of thermionic emission – White dwarfs.

PRACTICALS/ASSIGNMENTS/SEMINARS/GROUP DISCUSSIONS:

- Formulation of Lagrange's equations for different mechanical systems
- Bringing out the Hamilton's equations for various mechanical systems
- Comparison of Newtonian, Lagrangian and Hamiltonian formulations
- Solution for Kepler's problem by Hamilton Jacobi method
- Problems to show that the transformation is canonical
- Most probable speed, Mean speed, Mean square speed and Root mean square speed calculations
- Comparative study of classical and quantum statistics

PEDAGOGY STRATEGIES

- Board and chalk lecture
- Powerpoint presentations
- Assignments
- Seminars
- Group discussions
- Quizes

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6. S.K. Roy, Thermal Physics and Statistical Mechanics, New Age International, 2014.
7. Mehran Kardar, Statistical Physics of Particles, Cambridge University Press, 2007.
8. R. K. Pathria and Paul D. Beale, Statistical Mechanics, Butterworth-Heinemann, 2011.

WEB-RESOURCES:

1. https://ocw.mit.edu
2. https://nptel.ac.in
3. https://freevideolectures.com
4. https://www.coursera.org
5. http://www.courses.physics.helsinki.fi
6. https://www.researchgate.net

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcome (CLO)						
	1	2	3	4	5	6	7
Disciplinary Knowledge	✓	✓		✓			
Communication Skills					✓		
Critical Thinking	✓	✓					
Research-related Skills		✓		✓			
Analytical Reasoning		✓	✓			✓	✓
Problem Solving		✓	✓				✓
Team Work			✓		✓	✓	
Moral and Ethical Awareness							
Multicultural Competence					✓		

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	**Core 2: Quantum Mechanics - I**	**I**	**21MPH12C**	**5**

COURSE LEVEL OUTCOMES:

On the successful completion of the course, students will be able to

CLO-1	Discuss the of development of quantum mechanics
CLO-2	Recognize operators and state-vectors in Schrodinger, Heisenberg and Dirac Picture representations
CLO-3	Solve the Schrödinger equation for standard systems and interpret the results.
CLO-4	Analyze the concepts of spin and angular momentum, as well as their quantization and addition rules
CLO-5	Solve problems in angular momentum operators using Clebsh Gordan coefficient
CLO-6	Recognize the concepts of perturbation for degeneracy and non-degeneracy cases and hence make students to learn various approximation methods.
CLO-7	Outline the physical states of elementary particles and atoms in different systems based on quantum mechanics.

UNIT I: General formalism of quantum mechanics
Hilbert Space – Linear Operator – Eigen Functions and Eigen Values – Hermitian Operator – Postulates of Quantum Mechanics – Simultaneous Measurability of Observables – General Uncertainty Relation – Dirac's Notation – Equations of Motion; Schrodinger, Heisenberg and Dirac representation – Momentum representation.

UNIT II: Energy Eigen value problems
Particle in a box – Linear Harmonic oscillator – Tunneling through a barrier – Particle moving in a spherically symmetric potential – System of two interacting particles – Rigid rotator – Hydrogen atom

UNIT III: Angular Momentum
Orbital Angular Momentum – Spin Angular Momentum – Total Angular Momentum Operators – Commutation Relations of Total Angular Momentum with Components – Ladder operators – Commutation Relation of J_z with J_+ and J_- – Eigen values of J^2, J_z – Matrix representation of J^2, J_z, J_+ and J_- – Addition of angular momenta – Clebsch Gordon Coefficients – Properties

UNIT IV: Approximation Methods
Time Independent Perturbation Theory in Non-Degenerate Case – Normal He atom – Degenerate Case – Stark Effect in Hydrogen atom – Variation Method –WKB Approximation and its validity condition – Transmission through a barrier.

UNIT V: Many electron atoms
Indistinguishable particles – Pauli principle – Inclusion of spin – Spin functions for two-electrons – The Helium Atom – Central Field Approximation – Thomas-Fermi model of the Atom – Slateer rules – Examples – Hund's rule – Hartree Equation – Hartree-Fock equation – Treatment of molecules – Born-Oppenheimer approximation – Feynman rules.

PRACTICALS/ASSIGNMENTS:

- Gravitational bound state
- Superposition state in the Infinite Potential well
- Weakly bound electron
- Unitary operators and Significance of Unitary transformation
- The world is full of Fermions

PEDAGOGY STRATEGIES:

- Board and chalk lecture
- Powerpoint slide presentations
- Assignments
- Seminars

REFERENCES:

1. P.M. Mathews & K. Venkatesan, A Text Book of Quantum Mechanics, Tata McGraw Hill, 4th Edition, (2010)
2. G. Aruldhas, Quantum Mechanics, Prentice Hall of India, 8th Edition, (2006)
3. Gupta, Kumar, Sharma, Quantum mechanics, Jai Prakash Nath Publications, 10th Edition, (2009)
4. L.I Schiff, Quantum Mechanics, McGraw Hill, 2nd Edition, (1968)
5. A. Devanathan, Quantum Mechanics, Narosa Publishing, 4th Edition (2000)
6. Sathya Prakash, Quantum Mechanics, Kedar Nath and Ram Nath, 9th Edition (2002)
7. R. Shankar, Principles of Quantum Mechanics, Plenum, 2nd Edition, (1994)

FURTHER READING:

1. A. Das, Lectures on Quantum mechanics, Hindustan Book Agency, 4th Edition, (2003)
2. J. J. Sakurai, Modern Quantum Mechanics, Addison-Wesley Publishing Company, 2nd Edition, (1994)
3. E. Merzbacher, Quantum Mechanics, Wiley, 5th Edition, (2014)
4. Robert Eisberg and Robert Resnick, Quantum Physics, John Wiley, 2nd Edition, (1985)
5. A. K. Ghatak and S. Lokanathan, Quantum Mechanics Theory and Applications, Macmillan, 3rd Edition, (1998)
6. D. J. Griffiths, Introduction to Quantum Mechanics, Pearson, 2nd Edition, (2012)
7. Nouredine Zettili, Quantum Mechanics Concepts and Applications, Wiley, 2nd Edition, (2009)

WEB-RESOURCES:

1. https://www.rpi.edu
2. https://www.quantummechanics.ucsd.edu
3. https://www.openstax.org
4. https://www.chem.libretexts.org
5. https://www.hyperphysics.phy.edu

6. https://www.youtube.com/watch?v=pGerRhxNQJE&list=PLbMVogVj5nJTXGlgqyzpUqozrU55oRX-H&index=1

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcome (CLO)						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Disciplinary Knowledge	✓		✓	✓		✓	✓
Communication Skills	✓						
Critical Thinking	✓		✓	✓	✓	✓	
Research-related Skills		✓		✓	✓		✓
Analytical Reasoning	✓	✓			✓	✓	✓
Problem Solving		✓	✓	✓	✓	✓	
Team Work	✓						
Moral and Ethical Awareness							
Multicultural Competence							

Year	Subject Title	Se m	Sub Code	Hours/ Week
2021-22 Onwards	Core 3: Mathematical Physics	I	21MPH13C	5

COURSE LEVEL OUTCOMES:

On the successful completion of the course, students will be able to

CLO-1 Discuss complex analysis and solve problems using important theorems
CLO-2 Interpret and solve differential equations by the method of separation of variables
CLO-3 Demonstrate special functions such as Bessel, Legendre, Hermite and Laguerre
CLO-4 Solve Fourier Integrals and create new problems
CLO-5 Communicate the significance of Fourier series
CLO-6 Analyse Laplace transform and related theorems
CLO-7 Recognize group theory and identify the structure of molecules

UNIT I: Complex Variables
Function of a complex variable – Analytic function – Harmonic functions – Problems – Complex integration – Cauchy's theorem – Cauchy's integral formula – Taylor's expansion – Laurent's expansion – Residue and contour integration – Cauchy's residue theorem – Computation of residue –Evaluation of definite integrals (without Jordan's lemma).

UNIT II: Differential Equations and Special Functions
Bessel's equations – solution – Function of first kind – Half order function – Recurrence formulae – Generating function, Legendre's equations – solution – Polynomials – Generating function – Recurrence formulae – Rodrigue's formula – Orthogonal property, Hermite's equations-solution – Polynomials- Generating function – Recurrence formulae – Rodrigue's formula – Orthogonality property – General solution for Laguerre's differential functions – Applications of Differential equations.

UNIT III: Fourier series and Integrals
Definition – Evaluation of coefficients – Even and odd functions – Dirichlet's theorem and Dirichlet's conditions – half range series in interval 0 to π – change of interval from (-π, π) to (-l, l) – complex form of Fourier series – Fourier series in interval (0, T) – uses of Fourier series – physical examples (square, saw tooth and triangular) – properties – Gibb's phenomenon- Parseval's Identity – Fourier Integrals.

UNIT IV: Laplace Transform
Definition – conditions for existence and proof of their validity – properties – Laplace transform of some simple functions – Laplace transform of derivative – Laplace transform of an integral – Laplace transform of periodic functions – Inverse Laplace transform – Fourier Mellin theorem – Evaluation of inverse Laplace transform by Bromwich integral – properties –Convolution Theorem-Applications of Laplace transform.

UNIT V: Group Theory
Concept of group – Abelian groups – Generation of finite group – Group multiplication table –Rearrangement theorem – subgroup – Lagrange theorem – Cosets – Conjugate

elements and classes – Normal subgroups – Factor groups – Isomorphism and Homomorphism – group of symmetry of an equilateral triangle and square.

PRACTICALS/ASSIGNMENTS:

Using MATLAB Program evaluate single and double integrals.
Using C++ Program plot Legendre Polynomials.

PEDAGOGY STRATEGIES:

- Board and chalk lecture
- Powerpoint slide presentations
- Assignments
- Seminars
- Group discussions

REFERENCES:

1. Sathyaprakash, Mathematical Physics with Classical Mechanics, Sulthan Chand, 2014
2. B.D Gupta, Mathematical Physics, Vikas Publishing House, 2nd Edition, 1997
3. Rajput, Mathematical physics, Pragathi Prakashan, 2017
4. Joshi ,Elements of Group theory for Physicists, Wiley Eastern, New Age International, 2009
5. H.K.Dass, Dr.Rama Verma, Mathematical Physics, S.Chand, 2008

FURTHER READING:

1. John.S.Rose, A course on Group theory, Kindle Edition,2003
2. Georgi.P.Tolstov, Fourier Series, Prentice Hall, I edition, 1962
3. James.C.Nearing, Mathematical Tools for Physics, Dove Publications,2004

WEB-RESOURCES:

1. http://www.freebookcentre.net/Physics/Mathematical-Physics-Books.html
2. https://www.physicsbyfiziks.com/learn_physics/Mathematical_Physics/
3. https://nptel.ac.in/courses/115/106/115106086/

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES

	Course Level Outcomes (CLO)						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Disciplinary Knowledge		✓	✓	✓	✓	✓	✓
Communication Skills					✓		
Critical Thinking		✓	✓	✓	✓	✓	✓
Research-related skills	✓			✓		✓	✓
Analytical reasoning	✓					✓	✓
Problem Solving	✓	✓	✓	✓	✓		✓
Team work		✓	✓		✓		

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	Elective-I: Problems in Physics – I	I	21MPH14E	3

COURSE LEVEL OUTCOMES:

On the successful completion of the course, students will be able to

CLO-1 Recognize the concepts of mathematical physics and classical mechanics could be applied to formulate problems and solve them using mathematical tools.
CLO-2 Design to articulate and support complex problems, construct and examine logical soundness of solving problems.
CLO-3 Analyze the phenomena of Fourier series and Laplace transforms and distinguish their use in selecting appropriate tool in solving complex problems.
CLO-4 Create skills to identify problems in mathematical methods of physics and classical mechanics from unexplored areas and solve them using new technology
CLO-5 Utilize their creativity and insight to solve problems, interpret data and put forth the findings effectively.
CLO-6 Apply the experience to move from known to unknown, simple to complex, and theory to practical
CLO-7 Prepare to crack highly competitive examinations and have a career in public sector enterprises

Unit I: Mathematical Methods of Physics-I
Dimensional analysis - Vector algebra and vector calculus - Linear algebra – matrices – Cayley Hamilton Theorem – Eigen values problems - Linear ordinary differential equations - Special functions (Hermite, Bessel, Laguerre and Legendre functions)

Unit II: Mathematical Methods of Physics-II
Fourier series - Fourier and Laplace transforms - Elements of complex analysis - Laurent series; poles, residues and evaluation of integrals – Elementary ideas about tensors - Introductory group theory - SU(2), O(3)

Unit III: Mathematical Methods of Physics-III
Elements of computational techniques - root of functions, interpolation, extrapolation, integration by trapezoid and Simpson's rule, Solution of first order differential equation using Runge-Kutta method - Finite difference methods - Elementary probability theory, random variables, binomial, Poisson and normal distributions.

Unit IV: Classical Mechanics-I
Newton's laws - Phase space dynamics, stability analysis - Central force motions - Two body Collisions, Scattering in laboratory and Centre of mass frames - Rigid body dynamics, moment of inertia tensor, non-inertial frames and pseudo forces

Unit V: : Classical Mechanics-II
Variational principle, Lagrangian and Hamiltonian formalism and equations of motion - Poisson brackets and canonical transformations - Symmetry, invariance and conservation laws and cyclic coordinates - Periodic motion: small oscillations, normal modes - Special theory of relativity, Lorentz transformations, relativistic kinematics and mass–energy equivalence.

PRACTICALS/ASSIGNMENTS:

1. Matlab program to solve following numerically problems of mathematical physics and classical mechanics.
    a. Laplace's equation with boundary values
    b. Poisson's equation with boundary values
    c. Finding eign values using matrices
    d. Simultaneous equation solutions
    e. Single and double integral problems
    f. Plotting two and three dimensional curves and solve by extra pollution methods
    g. Harmonic and non-harmonic motions of rigid bodies
2. Seminars on formulating problems and constructing simple steps to solve them
3. Quizzes on transcendental equation, difference equations interpretation of data from graph, charts and histograms
4. Assignments in identifying latest research problems from journals and researchers working on them
5. Developing standard models in solving simple problems.
6. Group discussion in solving a problem using different mathematical tools and finding a simplest technique among them

PEDAGOGY STRATEGIES:

- Board and chalk lecture
- Powerpoint slide presentations
- Assignments
- Seminars
- Group discussions
- Quizes

REFERENCES:

1. CSIR-UCG NET/JRF/SET Physical Science by Dr.Surekha Tomar
   Upkar Prakahan, Agra (NOTE: Problems only from Book for Study

FURTHER READING:

1. Advance Engineering Mathematics by Kreyzig, Wiley Eastern
2. Mathematical Physics by Arfen and Weber
3. Mathematical Physics by BD Gupta, Vikas Publishing House 2nd Edition 1997
4. Classical Mechanics by Herbert Goldstein
5. Classical Mechanics by Satya Prakash

WEB-RESOURCES:

1. https://arxiv.org/ftp/physics/papers/0608/0608268.pdf

2. http://www.csun.edu/science/courses/525/old_files/thinking/probsolv_physics.htm
3. https://youtu.be/wFUSSgEAIyA
4. https://irp-cdn.multiscreensite.com/721e955d/files/uploaded/Solved%20Problems%20in%20Classical%20Mechanics%20.pdf
5. https://youtu.be/NbWVI7LnUmo

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES

	Course Level Outcomes (CLO)						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Disciplinary Knowledge	✓						
Communication Skills		✓					✓
Critical Thinking		✓	✓	✓	✓	✓	
Research-related skills	✓		✓	✓		✓	
Analytical reasoning	✓			✓			
Problem Solving	✓	✓	✓		✓		
Team work					✓	✓	✓
Moral and ethical awareness						✓	
Multicultural Competence	✓						

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	**Core 4: Quantum Mechanics – II**	**II**	**21MPH21C**	**5**

COURSE LEVEL OUTCOMES:

On the successful completion of the course, students will be able to

CLO-1 Deduce the time dependent perturbation theory
CLO-2 Construct the scattering theory in terms of quantum aspects
CLO-3 Recognize the relation between relativistic theory and quantum mechanics
CLO-4 Explain radiation theory on the basis of semi classical treatment.
CLO-5 Apprehend quantum field theory through classical approach
CLO-6 Apply time dependent perturbation theory to semi classical theory of radiation
CLO-7 Solve Dirac's equation in electromagnetic field

UNIT I: Time Dependent Perturbation Theory
Time Dependent Perturbation Theory – First and Second Order Transitions – Transition to Continuum of States – Fermi Golden Rule – Constant and Harmonic Perturbation – Collision –Adiabatic and Sudden Approximation – Charged Particle in an Electromagnetic Field.

UNIT II: Quantum theory of scattering
Scattering Amplitude – Expression in terms of Green's Function – Born Approximation and Its validity – Partial wave analysis – Phase Shifts – Asymptotic behaviour of Partial Waves – The Scattering Amplitude in Terms of Phase Shift – Scattering by square well Potential and Gaussian Potential.

UNIT III: Theory of Radiation (Semi Classical Treatment)
Einstein's Coefficients – Spontaneous and Induced Emission of Radiation from Semi Classical Theory – Radiation Field as an Assembly of Oscillators – Interaction with Atoms – Emission and Absorption Rates – Density Matrix and its Applications.

UNIT IV: Relativistic Wave Equation
Klein Gordon Equation – Plane Wave Equation – Charge and Current Density – Application to the Study of Hydrogen Like atom – Dirac Relativistic Equation for a Free Particle – Dirac Matrices – Dirac Equation in Electromagnetic Field – Negative Energy States.

UNIT V: Quantum Field Theory
Quantization of Wave Fields – Classical Lagrangian Equation – Classical Hamiltonian Equation – Field Quantization of the Non-Relativistic Schrodinger Equation – Creation, Destruction and Number Operators – Anti Commutation Relations – Quantization of electromagnetic field energy and momentum.

ASSIGNMENTS:

- Harmonic perturbation
- Determination of scattering amplitude by Partial wave analysis
- Dirac's hole theory of positron
- Quantization of the Non-Relativistic Schrodinger Equation

- Density matrix and its applications

PEDAGOGY STRATEGIES:

- Board and chalk lecture
- Powerpoint slide presentations
- Assignments
- Seminars

REFERENCES:

1. Satya Prakash, Advanced Quantum Mechanics, Kedar nath Ram nath, Meerut, 2004
2. S.L. Gupta, V. Kumar, H.V. Sharma, Quantum Mechanics, Jai Prakash Nath & Co., 2007
3. V. Devanathan , Quantum Mechanics, Narosa Publishing, New Delhi, 2005
4. PM.Mathews & K Venkatesan, Text Book of Quantum Mechanics, Tata McGraw Hill 2010
5 B.S. Rajput, Advanced Quantum Mechanics, Pragati Prakashan, Meerut, 2016

FURTHER READING:

1. G Aruldhas, Quantum Mechanics, Prentice Hall of India, 2006
2. David J.Griffiths Pearson, Introduction to Quantum Mechanics, Prentice Hall, 2005
3. L.I Schiff, Quantum Mechanics, McGraw Hill, 1968
4. A.K. Ghatak and S. Loganathan ,Quantum Mechanics, McMillan India, 2004
5. R.Shankar, Principles of Quantum Mechanics, Springer 2005

WEB-RESOURCES:

1. http://staff.ustc.edu.cn/~yuanzs/teaching/Fermi-Golden-Rule-No-II.pdf
2. https://www.chm.uri.edu/dfreeman/chm532/aa.pdf
3. http://bohr.physics.berkeley.edu/classes/221/1112/notes/kleing.pdf
4. https://sites.ualberta.ca/~gingrich/courses/phys512/node26.html
5. https://quantummechanics.ucsd.edu/ph130a/130_notes/node490.html

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcomes (CLO)						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Disciplinary Knowledge	✓		✓	✓	✓	✓	
Communication Skills							
Critical Thinking	✓	✓	✓		✓	✓	✓
Research-related skills		✓		✓		✓	✓
Analytical reasoning	✓	✓	✓			✓	
Problem Solving	✓			✓	✓	✓	✓
Team work						✓	
Moral and ethical awareness							
Multicultural Competence							

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	**Core 5: Computational Physics**	**II**	**21MPH22C**	**5**

COURSE LEVEL OUTCOMES:

On the successful completion of the course, students will be able to

CLO-1 Interpret the basic concepts of algebraic and transcendental equations
CLO-2 Develop various techniques and methods of solving ordinary differential equations
CLO-3 Connect important concepts and mathematical methods in order to enhance understanding the object oriented programming
CLO-4 Analyze the problems and develop the programs using C++
CLO-5 Execute the numerical problems with the help of Object Orienting Programming
CLO-6 Use features of C++ like type conversion, inheritance, polymorphism, I/O streams and files to develop programs for Numerical problems.
CLO-7 Test the numerical interpolation techniques in real life situations

Unit I: Solution of equations
Solution of algebraic transcendental equations - Bisection method - iteration method and Newton-Raphson method - Solution of Simultaneous linear algebraic equations - Gauss elimination method, Triangularisation method and inverse of matrix using Gauss elimination method - Solution of ordinary differential equations - Euler's method , Modified Euler's method and Fourth order Runge-kutta method - Solution of Partial Differential equations - Laplace's equation (Liebmann's iteration)- Poisson's equation

Unit II: Curve Fitting, Interpolation, differentiation and Integration
The least squares method for fitting a straight line, parabola, and exponential curves - Interpolation, Newton's forward and backward interpolation formula - Newton's divided difference interpolation formula and Lagrange's interpolation formula - Numerical differentiation - Newton's forward and backward difference formula to compute derivative - Numerical integration, Newton-Cote's formula- Trapezoidal rule - Simpson's one third rule

Unit III: Object- Oriented Programming
Basic concepts-procedure – paradigm - objects-Classes - Data abstraction and encapsulation -inheritance – Polymorphism - Dynamic binding - Message passing - Structure of C++ program –Tokens – Keywords - Identifiers and constants - Basic data types - User defined data types -Derived data types - symbolic constants - Type compatibility - Declaration of variables - Dynamic initialization of variables - Reference variables

Unit IV: Operators in C++
Scope resolution operators - Member dereferencing operators - Memory management operators –Manipulators - Type cast operators - Expression and their types – Special assignment expressions -Implicit conversions - operator over loading - Operator precedence - Control structures

Unit V: Functions in C++
The main function - Function prototyping - Call by reference - Return by reference - In line functions-Default arguments - Constant arguments - Function overloading - Friend and virtual functions - Math library functions.
PRACTICALS/ASSIGNMENTS:

1. C++ Program to fit a straight line
2. C++ Program to solve nonlinear equations, system of linear equations using Newton-Raphson method
3. C++ Program to evaluate Integral using Trapezoidal and Simpson's rule
4. C++ Program to solve the first order differential equation using Runge-Kutta method
5. Write the C++ program to find the correct root of the equations using Bisection method
6. Derive Laplace equation for the solution of partial differential equations.
7. Execute and solve the problems using the interpolation formulas with respect to C++ program

PEDAGOGY STRATEGIES:

- Board and chalk lecture
- Powerpoint slide presentations
- Assignments
- Seminars
- Laboratory classes

REFERENCES:

1. P. Kandasamy, K.Thilagavathy& K.Gunavathy, Numerical method, S.Chand &co.ltd 2010
2. E.balagurusamy, Object Oriented Programming with C++ TMH, 2011
3. M.k.Venkataraman, Numerical Methods in Science& Engineering, The national Pub, 2004
4. Bjarne Stroutstrup, The C++ Progamming Language, Benjamin and Cummins Pub, 1991
5. E. Balagurusami, Numerical Methods,Tata McGraw Hill, 2009

FURTHER READING:

1. J.B. Scarborough, Numerical Mathematical Analysis, 1958
2. M.K Jain,S.R.K Iyengar, R.K. Jain, Numerical methods for scientific and Engineering computation ,New Age International Publishers 2016
3. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI Pvt. Ltd. 2012
4. D Ravichandran, Programming with C++, Second edition, Tata McGraw- Hil,2003
5. Ashok N. Kamthane, Object oriented Programming with ANSI & Turbo C++, Pearson India,2006

WEB-RESOURCES:

1. Research Gate
2. NPTEL
3. Programiz
4. Cplusplus
5. TechStudy

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcomes (CLO)						
	1	2	3	4	5	6	7
Disciplinary Knowledge	✓	✓	✓				✓
Communication Skills			✓				✓
Critical Thinking	✓	✓	✓	✓	✓		✓
Research-related skills		✓		✓	✓	✓	
Analytical reasoning		✓	✓		✓	✓	✓
Problem Solving	✓	✓	✓	✓	✓	✓	
Team work		✓		✓	✓		✓
Moral and ethical awareness	✓		✓	✓		✓	
Multicultural Competence	✓	✓		✓	✓		✓

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	**Core 6: Electromagnetic Theory**	**II**	**21MPH23C**	**5**

COURSE LEVEL OUTCOMES:

On the successful completion of the course, students will be able to

CLO-1 Outline the basics of electrostatics and magnetostatics and solve the problems in dielectric polarisation and electromagnetic potentials

CLO-2 Apply Maxwell's equations and apply Maxwell's equations to deduce wave equation and electromagnetic field energy

CLO-3 Analyze the phenomena of wave propagation in the free space, dielectric and conducting media

CLO-4 Discover the significance of Brewster's angle and polarization of E.M.Waves and calculate the degree of polarization at the boundary between two media

CLO-5 Explore the phenomenon of scattering by a free electron and a bound electron

CLO-6 Explain the electromagnetic fields of moving charges and radiating systems and analyze their applications in antennas

CLO-7 Modify the Maxwell's equations when formulated in relativistic language and justify the munification of these two theories.

UNIT I: Electrostatics and Magnetostatics

Gauss law – Dielectric and its polarization – Electric displacement – Dielectric constant – Polarisibility – Polarisation of non-polar molecules: Lorentz equation for molecular field – Clausius-Mosotti relation – Polarisation of polar molecules: The Langevin equation – The Debye relation and study of molecular structure – Electrostatic energy – Current density – Biot Savart law – divergence and curl of B – Ampere's Circuital law – Lorentz force law – Magnetic scalar potential – Magnetic vector potential – Magnetisation and Magnetisation current – Magnetic Intensity, Magnetic Susceptibility and Permeability.

UNIT II: Field Equation and Propagation of EM waves

Equation of continuity – Displacement current – Maxwell's equations – Physical significance – Poynting vector – Electromagnetic potentials **A** and φ – Maxwell's equations in terms of electromagnetic potentials – Non-uniqueness of electromagnetic potentials and concept of gauge – Lorentz gauge – Propagation of electromagnetic waves in free space – Propagation of E.M.W. in isotropic dielectrics – Propagation of E.M.W. in anisotropic dielectrics – Propagation of E.M.W. in Conducting media – Wave guide (Rectangular).

UNIT III: Interaction of EM waves with matter

Boundary Conditions at the interface between two media – Reflection and refraction of electromagnetic waves – Kinematic and dynamic properties – Fresnel's formula – Brewster's law and Polarisation of electromagnetic waves – Total internal reflection and critical angle – Reflection from metallic surface.

Scattering and scattering parameters – Scattering by a free electron – Scattering by a bound electron – Dispersion: Normal and Anomalous – Dispersion in gases – Dispersion in liquids and solids.

UNIT IV: Fields of Moving Charges and Radiating Systems

Retarded potentials – Lienard-Wiechert potentials – Fields of a point charge in uniform rectilinear motion – Fields of a point charge in arbitrary motion – Radiation from an accelerated charged particle at low velocity – Radiation from an accelerated charged particle at high velocity.

Oscillating electric dipole – Radiation from an Oscillating dipole – Radiation from small current element – Radiation from a linear antenna (Half wave) and Antenna Arrays (Qualitative treatment).

UNIT V: Relativistic Electrodynamics

Purview of special theory of relativity – Four vectors and Tensors – Transformation equations for ρ and **J** – Transformation equations for **A** and φ – Transformation equations for field vectors **E** and **B –** Covariance of Maxwell's equations in 4-vectors – Covariance of Maxwell's equations in 4 –Tensor forms – Covariance and transformation law of Lorentz force.

ASSIGNMENTS/ SEMINARS/ GROUP DISCUSSIONS:

1. Applications of Gauss's Law and Biot-savart Law
2.Applications of magnetic scalar and vector potentials
3. Wave guides - TE and TM modes of propagation
4.Peculiarities of metallic reflection and the method of its verification
5. Dispersion in gases - Normal and Anomalous
6. Bremstrahlung radiation
7. Covariance of Maxwell's equations in 4-vector and 4-Tensor forms

PEDAGOGY STRATEGIES:

- Board and chalk lecture
- Powerpoint slide presentations
- Assignments
- Seminars
- Group discussions

REFERENCES:

1 Chopra and Agarwal, Electromagnetic Theory, K.Nath& Co., Meerut, 2007.
2 Gupta, Kumar and Singh, Electrodynamics, PragathiPrakasan, Meerut, 2005.
3 Sathya Prakash, Electromagnetic theory and electrodynamics, K.Nath& Co., Meerut, 2008.
4 J. D. Jackson, Classical Electrodynamics, Wiley Eastern Ltd., New Delhi , 1998.
5 D.J. Griffiths, Introduction to Electrodynamics, 3rd Ed., Benjamin Cummings, 1998.

FURTHER READING:

1 M.N.O. Sadiku, Elements of Electromagnetics, Oxford University Press, 2001.
2 T.L. Chow, Introduction to Electromagnetic Theory, Jones & Bartlett Learning, 2006.
3 M.A.W. Miah, Fundamentals of Electromagnetics, Tata McGraw Hill, 1982.
4 R.S. Kshetrimayun, Electromagnetic field Theory, Cengage Learning, 2012.
5 G. Lehner, Electromagnetic Field Theory for Engineers & Physicists, Springer, 2010.

WEB-RESOURCES:

1 https://cutt.ly/qndHSdU
2 https://cutt.ly/cndHT9k
3 https://cutt.ly/kndHv39
4 https://cutt.ly/4ndHdQV

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcomes (CLO)						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Disciplinary Knowledge	✓	✓		✓	✓		✓
Communication Skills	✓		✓		✓		✓
Critical Thinking	✓	✓		✓		✓	✓
Research-related skills			✓	✓			✓
Analytical reasoning	✓	✓	✓	✓	✓	✓	✓
Problem Solving	✓		✓	✓	✓		
Team work		✓				✓	✓
Moral and ethical awareness					✓		
Multicultural Competence							

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	**Elective-II: Problems in Physics – II**	**II**	**21MPH24E**	**3**

COURSE LEVEL OUTCOMES:

On the successful completion of the course, students will be able to

CLO-1 Recognize the concepts of quantum mechanics and electromagnetics could be applied to formulate problems and solve them using mathematical tools.
CLO-2 Design to articulate and support complex problems, construct and examine logical soundness of solving problems.
CLO-3 Analyze the phenomena of complex numbers and vector algebra and distinguish them to use in selecting appropriate tool in solving complex problems.
CLO-4 Create skills to identify problems in quantum physics, electrostatics, magnetostatics and electromagnetics from unexplored areas and solve them using new technology
CLO-5 Utilize their creativity and insight to solve problems, interpret data and put forth the findings effectively.
CLO-6 Apply the experience to move from known to unknown, simple to complex, and theory to practical
CLO-7 Prepare to crack highly competitive examinations and have a career in public sector enterprises

UNIT I: Quantum Mechanics –I
Wave-particle duality - Wave-function in coordinate and momentum representations - Commutators and Heisenberg’s uncertainty principle – Matrix representation – Dirac’s bra and ket notation - Schrödinger equation (time-dependent and time-independent) – Eigen value problems such as particle in a box, harmonic oscillator, etc.- Tunneling through a barrier - Motion in a central potential - Orbital angular momentum, Angular momentum algebra, spin - Addition of angular momenta - Hydrogen atom ,spin-orbit coupling, fine structure - Time-independent perturbation theory and applications

UNIT II: Quantum Mechanics - II
Variational method WKB approximation - Time dependent perturbation theory and Fermi's golden rule - Selection rules –Semi-classical theory of radiation – Elementary theory of scattering, phase shift, partial waves, Born approximation - Identical particles – Pauli’s exclusion principle - Spin-statistics connection – Klein Gordon and Dirac equations

UNIT III: Electromagnetic Theory - I
Electrostatics: Gauss’s law and its applications-Laplace and Poisson equations, boundary value problems- Magneto statics: Biot-Savart law, Ampere's theorem.

UNIT IV: Electromagnetic Theory - II
Electromagnetic induction-Maxwell's equations in free space and linear isotropic media-Boundary conditions on the fields at interfaces-Scalar and vector potentials- gauge invariance

UNIT V: Electromagnetic Theory - III Electromagnetic waves in free space, Dielectrics and conductors- Reflection and refraction, polarization, Fresnel’s law, interference, coherence, and diffraction- Dynamics of charged particles in static and uniform electromagnetic fields- Radiation from moving charges, dipoles and retarded potentials.

PRACTICALS/ASSIGNMENTS:

1. Practical classes will be conducted on the following topics to have firsthand knowledge about practical solutions of the problems from quantum and electromagnetic theorys
   a. Determination of wave lengths using Hartmann’s formula for arc spectral lines of different metals
   b. Tunnel diode characteristics to understand tunneling effect
   c. Mat lab programs for solving Pauli’s spin matrices and boundary value problems in electromagnetic
   d. Determination of electric and magnetic intensities for various shaped capacitors and dielectrics, circular coil and solenoid
   e. Study of radiation energy from different dipoles to find magnetic scalar and vector potentials
2. Seminars on formulating problems and constructing simple steps to solve them
3. Quizzes on klein-Gordon equations, Lande “g” factor, eigen values, potentials and fields for different functions and relativistic electromagnetic theory
4. Assignments in identifying latest research problems from journals and researchers working on them
5. Developing standard models in solving simple problems.
6. Group discussion in solving a problem using different mathematical tools and finding a simplest technique among them

PEDAGOGY STRATEGIES:

- Board and chalk lecture
- Powerpoint slide presentations
- Assignments
- Seminars
- Group discussions
- Laboratory classes
- Quizes

REFERENCES:

1. CSIR-UCG NET/JRF/SET Physical Science by Dr.Surekha Tomar
Upkar Prakahan, Agra (NOTE: Problems only from Book for Study

FURTHER READING:

1. Text Book of Quantum Mechanics -P.M. Mathews & K. Venkatesan-Tata McGraw Hill 2010

2. Quantum Mechanics – G Aruldhas - Prentice Hall of India 2006
3. Introduction to Quantum Mechanics – David J.Griffiths Pearson Prentice Hall, 2005
4. Sathya Prakash, Electromagnetic theory and electrodynamics, K.Nath& Co., Meerut
5. J. D. Jackson, Classical Electrodynamics, Wiley Eastern Ltd., New Delhi)
6. D.J. Griffiths, Introduction to Electrodynamics, 3rd Ed., 1998, Benjamin Cummings

WEB-RESOURCES:

1. https://youtu.be/ome04F3pKh0
2. https://nasim.hormozgan.ac.ir/ostad/UploadedFiles/1859694/1859694-1368629834498910.pdf
3. https://www.eolss.net/sample-chapters/C02/E6-04-04-01.pdf
4. https://youtu.be/rLHfkCBcRBs
5. https://youtu.be/EiX3R6IkDDU

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcomes (CLO)						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Disciplinary Knowledge	✓						
Communication Skills		✓					✓
Critical Thinking		✓	✓	✓	✓	✓	
Research-related skills	✓		✓	✓		✓	
Analytical reasoning	✓			✓			
Problem Solving	✓	✓	✓		✓		
Team work					✓	✓	✓
Moral and ethical awareness						✓	
Multicultural Competence							

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	**PRACTICAL – I – GENERAL EXPERIMENTS Examination at the end of SECOND Semester (Any 12)**	**I & II**	**21MPH25P**	**6**

COURSE LEVEL OUTCOMES:

On the successful completion of the course, students will be able to

CLO-1 Provide hands on experiences in performing scientific investigations and laboratory experiments

CLO-2 Acquire appropriate data accurately and maintain systematic record of the observations

CLO-3 Interpret the findings using the correct tools and framework and understand the safety measures in using physics instruments

CLO-4 Realize the fundamentals and applications of various fields of Physics

CLO-5 Prepare quality textural and graphical presentations of the data

CLO-6 Analyze the experimental results

CLO-7 Adopt skills related to education, research and industry-academia

1. Young’s Modulus – Elliptical fringes (Cornu’s Method)
2. Young’s Modulus – Hyperbolic fringes (Cornu’s Method)
3. Stefan’s constant
4. Rydberg’s constant – Solar Spectrum
5. e/m by Thomson’s Method
6. Thermal conductivity by Forbe’s Method
7. Specific heat of liquid by Ferguson’s method
8. Thermistor – Determination of Temperature co-efficient and Band gap energy
9. Diffraction at a prism table – Determination of wavelength
10. Four Probe Method – High Conductivity sample
11. Four Probe Method – Low Conductivity sample
12. Laser – Determination of refractive index of given liquids
13. Biprism on Optical bench – Determination of wavelength
14. Spectrometer - Hartmann’s constants – Determination of wavelength
15. Charge of an electron using spectrometer
16. Determination of Audio Frequency – Wien Bridge method
17. Velocity and Compressibility of a liquid – Ultrasonic method
18. Characteristics of Solar cell
19. Fizeau’s method – Linear expansion of solids
20. Determination of refractive index of a liquid by Air Wedge method
21. Determination of refractive index of a liquid by Newton’s ring method

22. Fresnel's biprism – Determination of the thickness of mica sheet.

REFERENCES:

1. D. Chattopadhyay and P.C. Rakshit, An advanced course in Practical Physics, New Central Book Agency, 8th Revised Edition, 2013
2. R.A. Dunlap, Experimental Physics: Modern methods, Oxford University Press, New Delhi, 1988
3. E.V. Smith, Manual for Experiments in Applied Physics, Butterworths, 1970
4. D. Malacara (Ed.), Methods of Experimental Physics, Series of volumes, Academic Press Inc., 1988

WEB-RESOURCES:

1. https://praxilabs.com/en/3d-science-simulations
2. https://vlab.amrita.edu/?sub=1&brch=189

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcomes (CLO)						
	1	2	3	4	5	6	7
Disciplinary Knowledge	✓	✓	✓	✓	✓	✓	✓
Communication Skills	✓			✓			✓
Critical Thinking		✓	✓	✓		✓	✓
Research-related skills			✓	✓		✓	✓
Analytical reasoning		✓	✓			✓	
Problem Solving		✓		✓	✓		
Team work					✓	✓	
Moral and ethical awareness							
Multicultural Competence							

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	**PRACTICAL – II: GENERAL ELECTRONICS Examination at the end of SECOND Semester (Any 12)**	**I & II**	**21MPH26P**	**6**

COURSE LEVEL OUTCOMES:

On the successful completion of the course, students will be able to

CLO-1 Identify semiconductor components and integrated circuits.
CLO-2 Review the characteristics of FET, UJT and Op. Amp.
CLO-3 Construct amplifier, oscillator, clipping, clamping and multivibrator circuits.
CLO-4 Observe and analyze the experimental data.
CLO-5 Draw characteristic and frequency response curves.
CLO-6 Design and analyze Filter circuits, D/A and A/D converter circuits.
CLO-7 Detect and discuss about the flaws in the circuits and rectify them.

1. Regulated and dual power supply construction
2. Hartley Oscillator using Transistor
3. Characteristics of FET
4. Common source FET amplifier
5. Characteristics of UJT
6. UJT relaxation oscillator
7. Adder, Subtractor, Sign changer and Scale changer using Op. Amp
8. Inverting amplifier, Non-inverting amplifier and Voltage follower using Op. Amp
9. Differentiator and Integrator using Op. Amp
10. Hartley Oscillator using Op. Amp
11. Astable multivibrator using Op. Amp
12. Astable multivibrator using IC 555
13. Bistable multivibrator using IC 555
14. RC coupled amplifier - Frequency response
15. Op. Amp as Schmitt trigger
16. Clipping and clamping circuits
17. D/A converter using Op. Amp
18. Design of Low pass, High pass and Band pass filters
19. Parameters of Op. Amp
20. Differential Amplifier – Op. Amp
21. Frequency response of an Op. Amp
22. Analog to Digital converter using IC 74148

PEDAGOGY STRATEGIES

- Board and chalk explanation
- Assignments

- Laboratory classes
- Quizes

REFERENCES:

1. R. K. Shukla and Anchal Srivastava, Practical Physics, New Age International, 2017.
2. C.C. Ouseph, U.J. Rao, V. Vijayendran, Practical Physics and Electronics, S. Viswanathan PP, 2009.

FURTHER READING:

1. Indu Prakash, Ram Krishna and A. K. Jha, A Textbook of Practical Physics, Kitab Mahal, 2011.
2. G. L. Squires, Practical Physics, Cambridge University Press, 2014.
3. Ralph Morrison, Practical Electronics, John Wiley & Sons Inc, 2003.
4. Paul Scherz and Simon Monk, Practical Electronics for Inventors, McGraw-Hill Education TAB, 2016.

WEB-RESOURCES:

1. https://www.niser.ac.in>sps>teaching-laboratories
2. https://www.ocw.mit.edu
3. https://www.edu.rsc.org

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcomes (CLO)						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Disciplinary Knowledge	✓	✓		✓			
Communication Skills					✓		
Critical Thinking	✓	✓				✓	
Research-related skills		✓		✓			
Analytical reasoning		✓	✓			✓	✓
Problem Solving		✓	✓				✓
Team work			✓		✓	✓	
Moral and ethical awareness							
Multicultural Competence					✓		

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	Core 7: Molecular Spectroscopy	III	21MPH31C	5

COURSE LEVEL OUTCOMES:

On the successful completion of the course, students will be able to

CLO-1 Classify molecules on the basis of Moment of Inertia and explain microwave and infra-red spectrum
CLO-2 Interpret Raman spectra
CLO-3 Demonstrate skills in collection of data, analysis using electronic and photo electronic spectroscopy
CLO-4 Describe nuclear spin and understand the theory and applications of NMR
CLO-5 Describe the basics of Mossbauer and NQR spectroscopy
CLO-6 Explain the principle of IR spectroscopy and make use of it in analyzing spectra
CLO-7 Solve problems related to structure and to study molecular interactions by choosing suitable spectroscopic methods and interpreting corresponding data

Unit I: Microwave Spectroscopy
Classification of molecules - Interaction of radiation with rotating molecule – Rotational spectra of rigid diatomic molecule – Isotope effect – Intensity of rotational lines – Non-rigid rotator – Rotational spectra of linear polyatomic molecules and symmetric top molecules – Microwave spectrometer.
Infra-red Spectroscopy: Vibrational energy of a diatomic molecule – Infrared selection rules – Simple Harmonic oscillator – Hot bands - Diatomic vibrating rotator – Vibration –Rotation spectra of linear and molecules and symmetric top molecules – IR spectrophotometer – Fourier Transform IR spectroscopy (Basic Ideas)

Unit II: Raman Spectroscopy
Principle – Classical Theory – Quantum Theory – Pure rotational Raman spectra of linear molecules – Vibrational coarse and rotational fine Raman spectra– Rule of mutual exclusion – Comparison between Raman and IR spectra – Raman Spectrometer.
Nonlinear Raman Phenomenon: Hyper Raman effect – Classical treatment – Experimental techniques – Stimulated Raman scattering – Inverse Raman effect – Coherent anti-stokes Raman scattering – Photo-acoustic Raman scattering

Unit III: Electronic Spectroscopy
The Born-Oppenheimer approximation – Vibrational course structure – Progressions and sequences – Frank Condon Principle – Rotational fine structure of electronic vibration spectra – Fortrat Diagram.
Photoelectron Spectroscopy: Principle – Instrumentation – Information from photoelectron spectra – Basic Ideas on ultraviolet photoelectron spectroscopy (UPES) and X-ray photo-electron spectroscopy (XPS)

Unit IV: : NMR Spectroscopy
Magnetic properties of nuclei - Resonance condition – Quantum description of Nuclear Magnetic Resonance - Rules predicting spin number of nuclei responding to NMR - Chemical shift – Spin-

lattice and spin-spin relaxation – Bloch equations and complex susceptibility – Line width.
ESR Spectroscopy: Comparison between NMR and ESR – Theory – Lande's splitting factor (g) – Hyperfine splitting – Instrumentation

Unit V: Mossbauer Spectroscopy
Recoilless emission and absorption – Instrumentation – Isomer shift – Quadrupole interaction – Magnetic hyperfine interaction.
NQR Spectroscopy: Theory – The quadrupole nucleus – Principle of NQR –Instrumentation.
Atomic Absorption Spectroscopy: Principle – Grotrian diagram – Distinction between atomic absorption and flame emission spectroscopy – Advantages and disadvantages of AAS – Instrumentation.

PROJECT/ASSIGNMENT:

- The whole process from preparing the sample, measurement on particular spectrometer and the analysis followed by the interpretation of different kind of molecular spectra.
- Advanced techniques of the evaluation and interpretation of obtained spectra.
- Assignment in listing the different regions of the electromagnetic spectrum with (i) wave number range and (ii) the wavelength in micrometers range.

PEDAGOGY STRATEGIES:

- Board and chalk lecture
- Powerpoint slide presentations
- Assignments
- Seminars

REFERENCES:

1. G. Aruldhas , Molecular Structure and Spectroscopy , Printice Hall of India, 2002
2. Banwell C N, Molecular spectroscopy, 2 nd Ed., New Delhi, TATA McGraw Hill Co., 2010
3. Gurdeep R Chatwal and Sham K Anand, Spectroscopy, Himalaya Publishing House, 2009
4. Gupta & Kumar, Elements of Spectroscopy, Pragathi Prakasan pub. Co., Meerut, 2007

FURTHER READING:

1. Straughan B P and Walker S, Spectroscopy Volume 1,2,3, New York, London Chapman and Hall, A Halstet Press Book, John Wiley & Sons Ins. 1975
2. Chang R, Basic Principles of Spectroscopy, New Jersey, Englewood Cliffs, 1978
3. S.L. Gupta and V. Kumar , Solid State Physics , K. Nath & Co.
4. Barrow G M, Introduction to Molecular Spectroscopy, Tata McGraw - Hill Ed., 1993

WEB-RESOURCES:

1. https://guide.library.queensu.ca
2. https://www.spectroscopyonline.com
3. https://www.classcentral.com
4. https://www.cv.nrao.edu

5. https://www.youtube.com/playlist?list=PLzPro5owUhRSV-ezegDDfuNpuJ2uU6jZ0

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcomes (CLO)						
	1	2	3	4	5	6	7
Disciplinary Knowledge	✓	✓	✓	✓	✓	✓	✓
Communication Skills	✓	✓	✓	✓	✓	✓	✓
Critical Thinking	✓	✓	✓	✓	✓	✓	✓
Research-related skills		✓	✓	✓	✓	✓	
Analytical reasoning	✓	✓	✓	✓		✓	
Problem Solving							✓
Team work	✓		✓				✓
Moral and ethical awareness							
Multicultural Competence							

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	**Core 8: Nuclear Physics**	**III**	**21MPH32C**	**5**

COURSE LEVEL OUTCOMES:

On the successful completion of the course, students will be able to

CLO-1 Explain the basic structure and properties of nuclei.
CLO-2 Classify various nuclear decays and solve problems in radioactivity
CLO-3 Summarize the characteristics of nuclear force in detail and gain knowledge about various nuclear models and potentials associated.
CLO-4 Analyze the types of nuclear reactions and understand the hazards of nuclear reactions
CLO-5 Understand and classify various types of nuclear reactors and recognize the safety of nuclear power plants
CLO-6 Classify the elementary particles and explain the conservations laws.
CLO-7 Explain quark model and discuss cosmic rays

UNIT I: Quantum Numbers
Quantum numbers for individual nucleons – Isospin – parity – Nuclear angular momentum – Nuclear magnetic dipole moment – Electric moments - Quadrupole moment.
Mass Spectroscopy: Basic components of mass spectroscopes - Bainbridge and Jordan mass spectrograph – Neir's double focussing mass spectrometer – Doublelet method of mass spectroscopy - Mass synchrometer.

UNIT II: Radioactivity
□-ray – Determination of q/m of □ particle – Determination of the charge and mass of □ particles – Range of □ particles – Range – Velocity – Energy – Life relations - □ particle spectra – Gamow's theory of □ decay
Beta ray – Determination of e/m of □ particles: Kaufmann's experiment - □ ray spectra – Magnetic spectrograph – Origin of the line and continuous spectrum – Neutrino hypothesis – Indirect method - Direct method – Energy half-life relationship - Fermi theory of □ decay
□ **ray** – Measurement of gamma ray energies – Origin of □ rays – Internal conversion – Internal pair creation – Nuclear isomerism.

UNIT III: Nuclear Forces
Nuclear forces – Properties – Charge independence – Spin dependence of nuclear forces – exchange forces – Meson theory of nuclear forces – Isotopic spin formalism.
Nuclear Models: Classification of nuclear models - Liquid drop model – Spontaneous fission – Activation energy – Shell model – Prediction of angular momenta of nuclear ground states by shell model – Collective model – Optical model.

UNIT IV: Nuclear Reactions
Kinds of reaction and conservation laws – Nuclear reaction kinematics –Cross section of nuclear reaction-Continuum theory of Nuclear reaction – Resonance – Breit and Wigner dispersion formula – Stagesof a nuclear reaction.
Nuclear Reactors: Four factor formula- Critical size of a reactor- classification of reactors – Pressurized Water Reactor – Boiling Water Reactor – Fast Breeder Reactor – Neutron cycle in a

thermal nuclear reactor – Fusion reactors – Biological and othereffects of nuclear radiations.

UNIT V: Particle Physics
Classification – Particle interaction – conservation laws – Strangeness – Hyper charge – Isospin – Charge conjugation – Parity – Time reversal –CP - CPT theorem – SU (3) Symmetry – Quarks – Quarks masses – Quantum numbers – Isospin of quarks.
Cosmic rays: Secondary cosmic rays - Geomagnetic effects-Interpretation of Geomagnetic effects-Absorption of cosmic rays – cosmic ray shower.

PRACTICALS/ASSIGNMENTS:

- Characteristics of GM Counter
- e/m by Magnetron method
- e/m by Zeeman Effect
- Assignment on 'Environmental impact of nuclear energy'
- Assignment on 'International Atomic Energy Agency (IAEA)'

PEDAGOGY STRATEGIES:

- Board and chalk lecture
- Powerpoint slide presentations
- Assignments
- Seminars
- Group discussions
- Laboratory classes

REFERENCES:

1. D. C. Tayal, Nuclear Physics, Himalaya Publication home, 2007.
2. R. R. Roy and B. P. Nigam, Nuclear Physics, New Age International Ltd., 2001.
3. Kaplan Irving, Nuclear Physics, Narosa Publishing House, 2000.
4. B. L. Cohen, Concepts of Nuclear Physics, TMGH, Bombay, 1971.
5. D. Griffiths, Introduction to Elementary Particles, 2nd Ed., Wily-Vch, 2008.
6. M.L, Pandya and R. P. S. Yadav , Elements of Nuclear Physics 7th edition, Kedar Nath Ram Nath, Delhi, 1995.
7. K.S. Krane, Nuclear Physics, Wiley India Pvt. Ltd., 2008.

FURTHER READING:

1. R. D. Evans, Atomic Nucleus, Tata McGraw-Hill, New York, 1955.
2. S.N. Ghoshal, Nuclear Physics, S Chand Publication, 2019.
3. S. B. Patel, An Introduction to Nuclear Physics (2nd Edition), New Age International, 2011.
4. J. M. Blatt and V. F. Weisskopf, Theoretical Nuclear Physics, Springer-Verlag New York 1979.
5. Harald A. Enge, Introduction to Nuclear Physics (1st Edition), Addison Wesley, 1996.
6. Arthur Beiser, Concepts of Modern Physics, 6^{th} Edition, Tata McGraw-Hill, New Delhi, 2008.
7. Kenneth S. Krane, Introductory Nuclear Physics (3rd Edition), Wiley, 1987.

WEB-RESOURCES:

1. https://www.psi.ch/sites/default/files/import/low-energy-muons/DocumentsEN/nuclear-moments.pdf
2. http://www.premierbiosoft.com/tech_notes/mass-spectrometry.html
3. https://wou.edu/chemistry/courses/online-chemistry-textbooks/ch103-allied-health-chemistry/ch103-chapter-3-radioactivity/
4. https://web.iisermohali.ac.in/Faculty/anoshjoseph/courses/2020_monsoon_nucl_phy/notes_lec08.pdf
5. https://phys.libretexts.org/Bookshelves/Nuclear_and_Particle_Physics/Book%3A_Nuclear_and_Particle_Physics_(Walet)/04%3A_Nuclear_Models
6. https://theconversation.com/explainer-what-are-fundamental-particles-38339
7. https://www.vox.com/the-highlight/2019/7/16/17690740/cosmic-rays-universe-theory-science

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcomes (CLO)						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Disciplinary Knowledge	✓	✓				✓	
Communication Skills	✓		✓			✓	✓
Critical Thinking			✓				
Research-related skills				✓	✓		
Analytical reasoning		✓	✓		✓		✓
Problem Solving		✓					
Team work							
Moral and ethical awareness				✓	✓		

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	**Core 9: Advanced Electronics and Microprocessor**	**III**	**18MPH33C**	**5**

COURSE LEVEL OUTCOMES:

On the successful completion of the course, students will be able to

CLO-1 Compile the steps involved in the fabrication of integrated circuits
CLO-2 Utilize analog and digital electronic devices to design simple circuits
CLO-3 Design operational amplifier circuits to realize various applications
CLO-4 Realize nonlinear analog systems such as ADC and DAC
CLO-5 Associate minimization techniques to select appropriate flip-flops to construct shift registers and counters
CLO-6 Integrate assembly language program with 8085 micorprocessor to construct application devices
CLO-7 Design, fabricate, test and run microprocessor programs

UNIT I: Integrated Circuits: Fabrication and Characteristics
Integrated circuit technology – Basic monolithic circuits – Epitaxial growth – Masking and etching – Diffusion of impurities – Transistor for monolithic circuits – Monolithic diodes – Integrated resistors- Integrated capacitors – Monolithic circuit layout – Additional isolation methods – LSI and MSI – Metal semiconductor contact.

UNIT II: Integrated Circuits as Analog System Building Blocks
Linear analog systems: Basic Op. Amp. applications – Sign changer – Scale changer – Phase shifter – Summing amplifier – Voltage to current converter – Current to voltage converter – DC voltage follower – Differential DC amplifier – Stable AC coupled amplifier – Analog integration and differentiation – Electronic analog computation
Nonlinear analog systems: Comparator – Sample and hold circuits – D/A converter: Binary weighted resister and ladder type – A/D converter: Simultaneous type, Counter type, Successive type and Dual-slop converters

UNIT III: Flip-flop, Minimization Techniques and Synchronous Counters
Flip-flops: S-R,Clocked S-R, D, J-K, T,Master-Slave J-K flip-flops – Their state diagrams and characteristic equations – Edge triggering in flip-flops
Boolean algebra and Minimization Techniques: Basic laws of Boolean algebra – De Morgan’s theorems – Sum-of-products and Product –of-sums - Karnaugh map (up to four variables only) –Don’t care conditions
Design of Synchronous Counters: Design of MOD-3, MOD-5, MOD-6, and MOD-10 counters using JK Master-slave flip-flops only – Register – 4-bit shift Register – Serial-in serial-out, Serial-in Parallel-out, Parallel-in Serial-out and Parallel-in Parallel-out – Ring counter – Design of four-bit self-correcting ring counter using D-flip-flop

UNIT IV: Microprocessors
8085 microprocessors – Microprocessor communication and bus timings – Demultiplexing the bus AD_7 - AD_0 – Generating control signals – A detailed architecture of 8085 microprocessor – 8085 machine cycles and bus timings – Opcode fetch machine cycle – Memory read machine cycle – Memory interfacing: Memory structure and its requirements

– Basic concepts in memory addresses interfacing – Address decoding – interfacing circuit – Address decoding and memory address interfacing the 8155 memory section

UNIT V: Programming the 8085

8085 programming model – Instruction classifications – Instruction and data format – 8085 Instructions: Data transfer operations – Logic operations – Branch operations – Programming techniques – Looping, counting and indexing – Additional data transfer and 16-bit arithmetic instructions – Counters and time delays – Simple programs – Addition, subtraction, multiplication, division, setting bits, masking bits

PRACTICALS/ASSIGNMENTS:

- Design and study of Wien Bridge Oscillator using Op. Amp
- Design and study of Phase shift Oscillator using Op. Amp
- Solution of differential equation using Op. Amp
- Solution of simultaneous equations using Op. Amp
- Op-amp as logarithmic and antilogarithmic amplifier
- Design of MOD 3 and MOD 5 counters using JK flip-flop
- Design of MOD 10 counter using JK flip-flop
- 8085 ALP for finding the largest/smallest number in an array and
- sum of a finite series
- 8085 ALP for sorting the array in ascending and descending order
- 8085 ALP for BCD to binary and binary to BCD
- Waveform generation using 8085
- LED interfacing using 8085
- Traffic light controller using 8085
- Stepper motor controller using 8085
- Digital clock using 8085

PEDAGOGY STRATEGIES:

- Board and chalk lecture
- Powerpoint slide presentations
- Assignments
- Seminars
- Laboratory classes

REFERENCES:

1. Millman and Hilkais, Integrated Electronics, Tata McGraw Hill Publications (1983).
2. S. Salivahanan, N. Suresh Kumar, ”Electronic Devices and Circuits”, Tata McGraw Hill Publications
3. Ramesh S. Gaonkar: Microprocessor Architecture, Programming and Application with the 8085-Penram International Publishing, Mumbai,6th edition,2013

FURTHER READING:

1. Roy D. Choudhury, Shail Jain, “Linear Integrated Circuits”, New Age International (P) Limited. 2002 Reprint

2. Ramakant A. Gayakwad, “Op-amps and Linear Integrated Circuits”, 4th Edition, Prentice Hall India, 2003
3. Victor P. Nelson, Digital logic circuit analysis and design, Prentice Hall, 1995
4. Albert Paul, Malvino, Digital Principles and Applications, McGraw Hill Publications, 1997
5. B. Ram: Fundamentals of microprocessors and microcomputers, DhanpatRai Publications, New Delhi, 5th edition, reprint 2003
6. V. Vijayendran: Fundamentals of microprocessor-8085- S. Viswanathan publishers, Chennai, 2009

WEB-RESOURCES:

1. http://www.analog.com/en/education/education-library/tutorials/
2. https://www.tutorialspoint.com/digital_electronics/index.asp
3. https://www.youtube.com/playlist?list=PL803563859BF7ED8C
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5. https://www.youtube.com/playlist?list=PLuv3GM6-gsE01L9yDO0e5UhQapkCPGnY3

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcomes (CLO)						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Disciplinary Knowledge	✓	✓		✓	✓	✓	
Communication Skills			✓				
Critical Thinking	✓	✓	✓			✓	✓
Research-related skills			✓				✓
Analytical reasoning		✓	✓		✓		✓
Problem Solving		✓		✓		✓	✓
Team work			✓				

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	Elective III: Problems in Physics – III	III	21MPH34E	3

COURSE LEVEL OUTCOMES:

On the successful completion of the course, students will be able to

CLO-1 Recognize the concepts of Atomic & Molecular Physics and Electronics could be applied to formulate problems and solve those using mathematical tools.

CLO-2 Design to articulate and support complex problems, construct and examine logical soundness of solving problems.

CLO-3 Analyze the phenomena of spectral lines formation, interpretation using fourier series, determining crystal structure using X-ray absorption/ emission, and distinguish them to use in selecting appropriate tool in solving complex problems.

CLO-4 Develop skills to identify problems from the needs of electronic industry and solve them using new technology

CLO-5 Utilize their creativity and insight to solve problems, interpret data and put forth the findings effectively.

CLO-6 Apply the experience to move from known to unknown, simple to complex, and theory to practical

CLO-7 Prepare to crack highly competitive examinations and have a career in public sector enterprises

UNIT I: Atomic & Molecular Physics - I

Quantum states of an electron in an atom- Electron spin-Stern and Gerlach experiment - Spectrum of helium and alkali atom-Relativistic corrections for energy levels of hydrogen atom- Hyperfine structure and isotopic shift- Width of spectrum lines

UNIT II: Atomic & Molecular Physics - II

L-S & J-J couplings- Zeeman, Paschen-Bach and Stark effects – X-ray spectroscopy - Electron spin resonance, NMR, chemical shift

UNIT III: Atomic & Molecular Physics - III

Rotational, Vibration, Electronic and Raman spectra of diatomic molecules- Frank Condon principle and selection rules - Spontaneous and stimulated emission, Einstein A & B coefficients - Optical pumping - Population inversion - Rate equation - Modes of resonators and coherence length.

UNIT IV: Electronics – I

Semiconductor device physics including diodes, junctions, transistors, field effect devices, homo- and hetero-junction devices, device structure, device characteristics, frequency dependence and applications - Opto-electronic devices including solar cells, photo-detectors, LEDs –High frequency devices including generators and detectors - Operational amplifiers and their applications

UNIT V: Electronics - II

Digital techniques and applications (registers, counters, comparators and similar circuits)- A/D and D/A converters - Microprocessor and Microcontroller basics.

PRACTICALS/SEMINAR/ASSIGNMENTS:

- Practicals
  - o Transistor biasing circuits
  - o FET biasing circuits
  - o Op. Amp based addition, subtraction, Schmitt trigger, Wein bridge, phase shift oscillators, A/D and D/A experiments
  - o Flip flop based counter circuits and their design
  - o Microprocessor programs

- Seminars on different spectroscopic techniques, design of electronic circuits and programming techniques in assembly language.

- Quiz programs on parameters of various electronic devices and electronic circuits.

- Assignments on Raman, NMR, NQR IR and microwave spectroscopy techniques, electronic devices characteristics, Karnaugh map simplifications, evolution of microprocessors.

PEDAGOGY STRATEGIES:

- Board and Chalk lecture
- Powerpoint slide presentations
- Assignments
- Laboratory classes
- Quizes
- Group Discussions

REFERENCES:

1. CSIR-UCG NET/JRF/SET Physical Science by Dr.Surekha Tomar
   Upkar Prakahan, Agra (Problems only from Book for Study)

FURTHER READING:

1. Straughan B P and Walker S, Spectroscopy Volume 1,2,3, New York, London Chapman and Hall, A Halstet Press Book, John Wiley & Sons Ins. 1975
2. Banwell C N, Fundamentals of Molecular spectroscopy, 2 nd Ed., New Delhi, TATA McGraw Hill Co., 2010
3. Gupta & Kumar, Elements of Spectroscopy, Pragathi Prakasan Publications Company Limited, Meerut, 2007
4. *G. M. Barrow* : *Introduction to molecular spectroscopy* , Mc Graw Hill boo Company , New York , 1962
5. S. Salivahanan, N. Suresh Kumar, "Electronic Devices and Circuits", Tata McGraw Hill Publications
6. S. Arivazhagan and S Salivahanan, Digital Circuits and Design, Vikas Publishing House Private Limited, 2009
7. Ramesh S. Gaonkar: Microprocessor Architecture, Programming and Application with the 8085-Penram International Publishing, Mumbai,6th edition,2013

WEB-RESOURCES:

1. https://youtu.be/SCmtEhGVhSM
2. https://www.fulviofrisone.com/attachments/article/356/Problems%20And%20Solutions%20On%20Atomic,.pdf
3. https://physicstoday.scitation.org/doi/10.1063/1.1897567
4. https://www.worldscientific.com/doi/pdf/10.1142/9789810248598_fmatter

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcomes (CLO)						
	1	2	3	4	5	6	7
Disciplinary Knowledge	✓						
Communication Skills		✓					✓
Critical Thinking		✓	✓	✓	✓	✓	
Research-related skills	✓		✓	✓		✓	
Analytical reasoning	✓			✓			
Problem Solving	✓	✓	✓		✓		
Team work					✓	✓	✓
Moral and ethical awareness						✓	
Multicultural Competence							

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	**Core 10: Material Science**	**IV**	**21MPH41C**	**5**

COURSE LEVEL OUTCOMES:

On the successful completion of the course, the students will be able to

CLO-1 Classify the different types of dielectric materials and analyze the temperature and frequency effects of different types of polarization mechanism.
CLO-2 Explain the magnetization character of various types of magnetic materials and compare their properties.
CLO-3 Outline the properties of modern materials and analyze their applications in various fields.
CLO-4 Identify the different types of semiconducting materials and their applications.
CLO-5 Describe the concept of superconductivity phenomenon and to acquire the knowledge of high transition temperature superconducting materials.
CLO-6 Discuss the thermal, mechanical, electrical, optical and magnetic properties of nano materials.
CLO-7 Apply the knowledge on synthesis of nanomaterials and to demonstrate some potential applications.

UNIT I: Dielectric Materials
Polarization – Dielectric constant – Different types of polarization – Electronic, ionic, orientational and space charge polarization – Frequency and temperature effects on different types of polarization– Dielectric loss – Local field – Clausius Mossotti relation – Dielectric breakdown – Different types of dielectric breakdown – Different types of dielectric materials – Properties and applications of dielectric materials – Ferroelectric materials – Hysteresis loop – Applications – Piezoelectric materials and their applications – Pyroelectric materials and their applications.

UNIT II: Magnetic Materials
Types of magnetic materials – Paramagnetic materials – Langevin theory of paramagnetism – Weiss theory of paramagnetism - Quantum theory of paramagnetism – Ferromagnetic materials – Ferromagnetic domains – Origin of domains – Exchange integral – Weiss theory of ferromagnetism – Antiferromagnetism – Neel Temperature - Molecular field theory of antiferromagnetism – Ferrites and their applications.

UNIT III: Semiconducting Materials and Modern Materials
Types of semiconducting materials – Mobility, drift velocity and carrier concentration of intrinsic semiconductor and extrinsic semiconductors – Variation of carrier concentration with temperature - Hall effect – Experimental determination of Hall coefficient.
Polymers – Plastics – Ceramics – High temperature materials – Thermoelectric materials – Nuclear engineering materials – Metallic glasses – Metal matrix composites – Biomaterials – Superhard materials – Shape memory alloys – Non-linear optical materials.

UNIT IV: Superconducting Materials
Superconductivity – Superconductors– Critical temperature and Critical magnetic field – Properties of superconducting materials – Meissner effect – Thermodynamics and Optical properties – Isotopic effect – Type I and type II superconductors – London equation – Penetration depth – Cooper pair – BCS theory – Coherence length – Recent trends in high transition temperature superconductors –

Superconducting magnets – Superconducting Quantum Interface Devices (SQUID) – Applications of superconducting materials.

UNIT V: Nanomaterials
Introduction – Synthesis of nanostructured materials –Top down and bottom up methods - Electrical, Optical, Thermal, Mechanical and Magnetic properties of nanomaterials – Functional nanoscale devices – Carbon nanotubes – Properties of carbon nanotubes - Structure of carbon nanotubes – Single wall and multi wall carbon nanotubes – Fabrication of carbon nanotubes – Laser ablation, electric arc discharge and chemical vapour deposition methods - Applications of carbon nanotubes - Quantum dot laser – Nanomagnet – Applications of nanomaterials .

PRACTICALS/ASSIGNMENTS:

- Synthesis of nanoparticles - Sol – Gel method, hydrothermal method and Co-precipitation method.
- Analysis of nanoparticles – X -ray diffraction, SEM, FT-IR, UV-Visible Absorption Spectroscopy, AFM, Photocatalytic activity.
- Prepare a model article based on a topic "Structure, Properties, Synthesis and Applications of carbon nanotubes".
- Collect data based on a topic "High Transition Temperature Superconductors".
- Prepare a model article based on a topic "Artificial Intelligence".

PEDAGOGY STRATEGIES:

- Board and chalk lecture
- Powerpoint slide presentations
- Assignments
- Seminars
- Laboratory classes

REFERENCES:

1. Solid State Physics, Gupta and Kumar, K. Nath & Co Ltd., Meerut, 2007.
2. Solid State Physics, Saxana, Gupta, Saxana, Pagati Prakashan, Meerut, 2005.
3. Solid State Physics, S.O.Pillai, New Age International (P) Limited, New Delhi, 2010.
4. Materials Science, M.Arumugam, Anuradha Publishers, Kumbagonam, 1989.
5. Nanostructured Materials, Parag Diwan and Ashish Bharadwaj, Pentagon Press, New Delhi, 2006.

FURTHER READING:

1. Solis State Physics, J.P.Srivastava, Prentice Hall of India (P) Ltd., New Delhi,2006.
2. Solid State Physics, Charles Kittel, John Willey Sons Asia (P) Ltd., Singapore, 1996.
3. Material Science and Metallurgy, O.P.Khanna, Dhanpat Raj Publications (P) Ltd., New Delhi, 2011.
4. Nanotechnlogy, Shalini Suri, APH Publishing Corporation, New Delhi, 2006.

5. A Handbook of Nanotechnology, U.Kumar, Agrobios (India), Jodhpur, 2012.

WEBRESOURCES:

1. http://www.matersci.net
2. http://www.web.pdx.edu
3. http://www.modern-materials.com
4. http://www.library.qmul.ac.uk
5. http://www.nano.com

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcomes (CLO)						
	1	2	3	4	5	6	7
Disciplinary Knowledge	✓	✓	✓	✓	✓	✓	✓
Communication Skills						✓	
Critical Thinking		✓	✓	✓	✓	✓	
Research-related skills	✓		✓	✓	✓	✓	✓
Analytical reasoning	✓		✓				
Problem Solving		✓					✓
Team work					✓	✓	✓

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	**Core 11: Optical and Thin Film Physics**	**IV**	**21MPH42C**	**5**

COURSE LEVEL OUTCOMES:

CLO-1 Describe the phenomenon of polarization and their types with applications.
CLO-2 Classify the types of LASER and their production methods with applications in various fields.
CLO-3 Discuss the basics of fibre optics and their classifications.
CLO-4 Associate the knowledge of optical fibres in various applications.
CLO-5 Apply different deposition techniques to prepare thin films.
CLO-6 Analyze the measurement of thickness, structural properties of thin films.
CLO-7 Develop familiarity with the vast areas of thin film preparation and characterization methods and ability to develop an interest in this area for future research work.

Unit I: Polarisation of light
Polarization – Partial polarization – Polarization by reflection – Polarization by refraction – Polarization by scattering – Circular and Elliptical polarization – Quarter wave plate – Matrix representation of polarization – The Jones calculus – Eigen vectors of Jones matrices – Dichroism –Polaroids. Half – Wave plate, Analysis of Polarized light, Babinet Compensator, Fresnel's Rhomb; Double Imaging Polarizing Prims; Applications of Polarized light; Electro-optic and magneto-optic Effects.

Unit II: Laser Physics
Laser – Characteristics of laser – Basic concepts of laser – Einstein's coefficients – Various pumping methods – Metastable states – Population inversion in three level and four level systems – Active medium – General laser system – Brewster's windows – Q –switching – Mode locking – Gain curve and laser operating frequencies – Neodymium laser – Carbon di oxide laser – Argon ion laser – Liquid laser – Dye laser – Semiconductor laser – Application of laser in various fields.

Unit III: Fibre optics
Basic principles – Total internal reflection – Fibre composition – Fibre dimensions – Fibre materials – Classification of optical fibres based on materials, modes and refractive index profiles – Acceptance cone – Numerical aperture – Transmission losses in optical fibre system components – LED, Laser, Photodiode and Avalanche Photodiode – Light wave communication using optical fibres – Applications in medical field.

Unit IV: Thin Film Deposition Techniques
Thermal evaporation: General considerations – evaporation methods: Resistance heating, Electron bombardment heating. **Sputtering**: Cathodic sputtering - Sputtering process - glow discharge sputtering - current and voltage dependence. **Chemical vapour deposition** - Vacuum deposition apparatus - Substrate deposition technology.

Unit V: Thickness Measurements and Characterization
Film thickness and its control-**Mass method**: Micro balance techniques -**Crystal Oscillator** - Quartz crystal thickness monitor with block diagram - **Optical method:** Interferometry -

Fizeau fringes method - FECO fringes method. **Structural Characterization** - XRD-Electron microscope-Types of electron microscope - Scanning electron microscope (SEM) - Transmission electron microscope (TEM) - Applications of SEM and TEM.

PRACTICALS:

- Assignment on ‘Matrix representation of polarization – The Jones calculus – Eigen vectors of Jones matrices’
- Laser experiments
- Demonstration of thin film coating using vacuum evaporation method
- Demonstration of thin film coating using spray pyrolysis method
- Demonstration of thin film coating using electroplating method

PEDAGOGY STRATEGIES:

- Board and chalk lecture
- Powerpoint slide presentations
- Assignments
- Seminars
- Laboratory classes

REFERENCES:

1. G.R.Fowles, Introduction to Modern Optics, Second Edition, Dover Publicatios,Inc., New York, (1989).
2. Langyerl, Introduction to Laser Physics,
3. Leon I Meisael and Reinherd Gleng, Handbook of Thin Film Technology, McGraw Hill Higher Education,(1970)
4. Goswami, Thin Film Fundamentals, New Age International New Delhi, (1996)
5. K.L. Chopra, Thin Film Phenomena, Krieger Pub Co,(1979)

FURTHER READING:

1. Ajoy Ghatak, Optics, McGraw Hill Education India Private Limited; Sixth edition, (2017).
2. K.R.Nambiar, Lasers: Principles, Types and applications, new age publishers; First edition (2004).
3. Subramaniam & Brijlal, M.N.Avadhanulu, Text Book of Optics,23rd edition,(2006)
4. Michael F Ashby, Paulo J Ferreira and Daniel L Schodek, Nanomaterials, Nanotechnologies and design, Elsevier Publishers, UK, 1st edition, (2009).
5. T.Pradeep, Nano The Essentials, Tata Mc Grow Hill, New Delhi, (2007).

WEB-RESOURCES:

1. https://ocw.mit.edu/resources/res-6-005-understanding-lasers-and-fiberoptics-spring-2008/fiberoptics-fundamentals/
2. https://nptel.ac.in/noc/noc_course.html
3. https://freevideolectures.com/course/5303/fundamentals-xray-diffraction-transmission-electron-microscopy

4. https://swayam.gov.in/courses
5. https://www.youtube.com/watch?v=kGfzOoAvaOM
6. https://www.youtube.com/watch?v=ev1EiLWgDIs

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcomes (CLO)						
	1	2	3	4	5	6	7
Disciplinary Knowledge	✓	✓			✓		✓
Communication Skills			✓				
Critical Thinking	✓	✓		✓		✓	
Research-related skills				✓	✓	✓	✓
Analytical reasoning	✓				✓		
Problem Solving		✓		✓		✓	
Team work			✓		✓		✓

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	Core 12: Condensed Matter Physics	IV	21MPH43C	5

COURSE LEVEL OUTCOMES:

On the successful completion of the course, students will be able to

CLO-1 Correlate crystal structure to symmetries and interpret XRD to analyze the structure
CLO-2 Recognize the correspondence between real and reciprocal space
CLO-3 Classify the defects based on their dimensions
CLO-4 Acquire knowledge about lattice vibrations
CLO-5 Realize the thermal properties of solids
CLO-6 Apply free electron theory for conductivity studies in metals
CLO-7 Identify the different optical phenomena in crystals

UNIT I: Reciprocal lattice
Unit cell – Space lattice – Bravais lattices – Miller indices – Interplanar spacing of lattice planes – Graphical construction of reciprocal lattice – Vector development of reciprocal lattice – Properties of reciprocal lattice – Reciprocal lattice to simple cubic, bcc and fcc lattice.
Crystal Diffraction: Bragg's law – correction – Bragg's law in three dimensions – Powder photograph method – Determination of unit cell dimensions – Diffraction of electrons and neutrons.

UNIT II: Imperfections in Crystals
Classification of defects – Zero, One and Two F' dimensional defects - Point defects – Schottky defect – Expression for number of vacancies – Frenkel defect – Expression for number of vacancies – Colour centres – F and centres – Line defects: Edge and Screw dislocation & Grain boundaries.
Types of Bonding: Ionic bonding – Energy of formation of NaCl molecule – Madelung Constant (linear array and three dimension) – Cohesive energy – Calculation of Repulsive exponent – Born-Haber cycle – Characteristics of ionic bond – Characteristics of covalent, metallic, molecular and hydrogen bonding.

UNIT III: Lattice vibrations
Elastic vibrations of continuous media – Wave motion of one dimensional monoatomic lattice – Group and phase velocities – Brillouin zones – Vibration of one dimensional diatomic lattice – Optical and acoustical branch – Forbidden frequency band – Facts about diatomic lattice.
Thermal properties of Solids: Classical theory of lattice specific heat – Einstien's theory – Debye's model – Debye approximation – Limitations.

UNIT IV: Free Electron theory of Metals
Free electron gas – Drude and Lorentz theory – Electrical and thermal conductivities – Wiedmann and Franz ratio – Variation of electrical resistivity with temperature –Sommerfeld quantum model – Energy levels, density of states and Fermi energy (in one dimension) Electronic Specific heat – Thermionic emission – Richardson and Dushman equation- Schottky effect – Failure of free electron model.

UNIT V: Band Theory of Solids
Energy spectra in atoms, molecules and solids – Wave equation in a periodic potential – Bloch theorem – Kronig-Penny model – Brillouin Zones in two dimensional square lattice – Distinction between metals, insulators and semiconductors.

Optical phenomena in Crystals: Photoconductivity – Absorption edge of crystals – Photosensitivity - Types of traps – Excitons – Luminescence.

PRACTICALS/ASSIGNMENTS:

1. Properties of Reciprocal lattice
2. Imperfections in crystals
3. Brillouin zones
4. Sommerfeld quantum model
5. Photoconductivity

PEDAGOGY STRATEGIES:

- Board and chalk lecture
- Powerpoint presentations
- Assignments
- Seminars
- Group discussions

REFERENCES:

1. S.L. Gupta and V. Kumar, Solid State Physics, K. Nath& Co. Ninth Edition, 2018.
2. Charles Kittel, Introduction to Solid State Physics, Wiley Eastern Ltd., 7th Edition, 2007.
3. A. J. Dekker, Solid State Physics, Macmillan India Ltd., 2000.
4. R.L. Singhal Solid State Physics , Kedar Nath Ram Nath & Co., 2018.
5. S.L. Kakani & C. Hemarajani, Solid State Physics, Sultan Chand & Sons., 2005.

FURTHER READING:

1. M.A. Wahab, Solid State Physics, 3rd Edition, Narosa Publishing House Pvt. Ltd., New Delhi, 2018.
2. H.P. Myers, Introductory Solid State Physics, 2nd Edition, Taylor and Francis, 1997.
3. Arun Kumar, Introduction to Solid State Physics, 2nd Edition, PHI Learning Pvt. Ltd. , 2015.
4. R.J. Singh, Solid State Physics, Pearson Education India, 2011.
5. Prathap Haridoss, Physics of Materials, Wiley India Pvt. Ltd., 2016.

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2. http://www.freebookcentre.net/Physics/Solid-State-Physics-Books.html
3. https://onlinecourses.nptel.ac.in/noc19_ph14/preview
4. https://phys.org/tags/solid+state+physics/
5. https://www.youtube.com/playlist?list=PLFW6lRTa1g83HGEihgwcy7KeTLUuBu3WF
6. https://www.youtube.com/playlist?list=PLXHedI-xbyr9_9pJqEBlHtEJl9EpbOMDd

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcomes (CLO)						
	1	2	3	4	5	6	7
Disciplinary Knowledge	✓	✓	✓	✓	✓	✓	✓
Communication Skills	✓				✓		✓
Critical Thinking		✓		✓		✓	✓
Research-related skills	✓					✓	✓
Analytical reasoning		✓		✓		✓	
Problem Solving				✓			
Team work	✓					✓	✓

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	Elective-IV: Problems in Physics – IV	IV	21MPH44E	3

COURSE LEVEL OUTCOMES:

On the successful completion of the course, students will be able to

CLO-1 Recognize the concepts of condensed matter physics and nuclear physics could be applied to formulate problems and solve those using mathematical tools.

CLO-2 Discuss complex problems, construct and examine logical soundness of solving problems.

CLO-3 Analyze the phenomena of absorption and emission spectral lines for identifying the composition of elements, their structures, bandgap energies and distinguish them to use in selecting appropriate concentration of elements to get desired bandgap energies for a particular application.

CLO-4 Develop skills to identify problems in condensed matter physics and nuclear physics from unexplored areas and solve them using new technology

CLO-5 Utilize their creativity and insight to solve problems, interpret data and put forth the findings effectively.

CLO-6 Apply the experience to move from known to unknown, simple to complex, and theory to practical

CLO-7 Prepare to crack highly competitive examinations and have a career in public sector enterprises

UNIT I: Condensed Matter Physics - I
Bravais lattices - Reciprocal lattice - Diffraction and the structure factor - Bonding of solids - Elastic properties, phonons, lattice specific heat - Free electron theory and electronic specific heat - Response and relaxation phenomena -Drude model of electrical and thermal conductivity - Hall Effect and thermoelectric power - Electron motion in a periodic potential

UNIT II: Condensed Matter Physics - II
Band theory of solids: metals, insulators and semiconductors - Superconductivity: type-I and type-II superconductors - Josephson junctions. Superfluidity - Defects and dislocations - Ordered phases of matter: translational and orientational order - kinds of liquid crystalline order Quasi crystals.

UNIT III: Nuclear and Particle Physics - I
Basic nuclear properties: size, shape and charge distribution, spin and parity - Binding energy, semi-empiricalmass formula, liquid drop model - Nature of the nuclear force, form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces - Deuteron problem - Evidence of shell structure, single-particle shell model, its validity and limitations - Rotational spectra

UNIT IV: Nuclear and Particle Physics - II
Elementary ideas of alpha, beta and gamma decays and their selection rules - Fission and fusion - Nuclear reactions, reaction mechanism, compound nuclei and direct reactions - Classification of fundamental forces

UNIT V: Nuclear and Particle Physics - III
Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.) - Gellmann-Nishijima formula -Quark model, baryons and mesons - C, P, and T invariance - Application

of symmetry arguments to particle reactions - Parity non-conservation in weak interaction - Relativistic kinematics

PRACTICALS/ASSIGNMENTS:

- Practicals
  a. Measurement of Hall coefficient
  b. Measurement of magnetic susceptibility
  c. B-H curve – hysteresis and laws of magnetism
  d. Measurement of band-gap energies
  e. Study of Geiger – Muller counter
- Assignments on crystal structures, packing fraction, no of atoms per unit cell, nuclear models, selection rules alpha, beta, gamma radiations, elementary particles and their models
- Quizzes in crystal defects, conservation laws on elementary particles, types of semiconductors, nuclear accelerators and nuclear detectors

PEDAGOGY STRATEGIES:

- Board and chalk lecture
- Powerpoint slide presentations
- Assignments
- Seminar
- Laboratory classes

REFERENCES:

1. CSIR-UCG NET/JRF/SET Physical Science by Dr. Surekha Tomar
Upkar Prakahan, Agra

FURTHER READING:

1. J.P.Srivastava, Solid State Physics, Prentice Hall of India (P) Ltd., New Delhi, Ed.2006.
2. Charles Kittel, Introduction to Solid State Physics, John Wiley Sons Asia (P) Ltd., Singapore, Ed., 1996.
3. Shalini Suri, Nanotechnology, APH Publishing Corporation, New Delhi, Ed. 2006
4. Arthur Beiser, Shobhit Mahajan, S Rai Choudhury, Concepts of Modern Physics, Tata McGraw-Hill, Higher Education, 2003
5. D. C. Tayal, Nuclear Physics, Himalaya Publishing House, 5th Ed., 2015

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1. https://www.physik.uzh.ch/dam/jcr:e04ec2a1-547a-4bbc-b0eb-0a9a3323dcb8/LECTURE-1-v1.pdf
2. https://youtu.be/_Ckh-60B6LY
3. https://youtu.be/4WC_5soO-Oc
4. https://youtu.be/H7OipY8RzX0
5. https://youtu.be/H7OipY8RzX0

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcomes (CLO)						
	1	2	3	4	5	6	7
Disciplinary Knowledge	✓						
Communication Skills		✓					✓
Critical Thinking		✓	✓	✓	✓	✓	
Research-related skills	✓		✓	✓		✓	
Analytical reasoning	✓			✓			
Problem Solving	✓	✓	✓		✓		
Team work					✓	✓	✓
Moral and ethical awareness						✓	

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	**PRACTICAL – III – ADVANCED EXPERIMENTS Examination at the end of IV Semester (Any 12)**	**IV**	**21MPH45P**	**6**

COURSE LEVEL OUTCOMES:

On the successful completion of the course, students will be able to

CLO-1 Design and conduct experiments that probe materials properties and apply math, computers and science concepts to the analysis of experimental data

CLO-2 Conversant with accuracy and precision, different types of errors and analysis of data using various software

CLO-3 Conduct Experiments using spectrometer, CDS, interferometer, Guoy balance, four probe apparatus, etc., and gain hands on experience and verify the theory

CLO-4 Develop communication skills (oral, graphic and written) and apply a methodology for materials selection to scientific problems

CLO-5 Predict the hazards of radiation and develop the safety measures to guard against these hazards

CLO-6 Identify /mobilizing appropriate resources required for a project, and manage a project through to completion, while observing responsible and ethical scientific conduct; and safety and laboratory hygiene regulations and practices

CLO-7 Work independently and function as a team

EXPERIMENTS

1. Brass Arc Spectrum – Constant Deviation spectrometer
2. Iron Arc Spectrum – Constant Deviation spectrometer
3. Copper Arc Spectrum – Constant Deviation spectrometer
4. Absorption Spectra using Constant Deviation spectrometer
5. Susceptibility by Quincke's method
6. Susceptibility by Guoy method
7. e/m by Magnetron method
8. e/m by Zeeman Effect
9. Study of PN junction – Determination of reverse saturation current and material constant
10. Study of PN junction – Determination of temperature co-efficient of junction voltage and Band gap energy
11. Study of PN junction – Study of depletion capacitance and its variation with reverse bias
12. Characteristic study of photo detectors using laser
13. Determination of Planck's constant
14. Study of Hall Effect in a semiconductor

15. Michelson's Interferometer – λ and dλ and thickness of mica sheet
16. Determination of wavelengths of Hg spectrum using double slit- Hartmann's formula
17. Kelvin's double bridge – Determination of very low resistance
18. Hysteresis curve – Magnetometer method
19. Determination of Band gap energy of a semiconductor – Four probe method
20. Characteristics GM Counter
21. Determination of wavelength of a laser source using diffraction grating and thickness of a wire
22. Rydberg constant using hydrogen discharge tube and grating
23. MATLAB Programming - Radioactive decay graph
24. MATLAB Programming - Single and double integration

PRACTICALS/ASSIGNMENTS/SEMINARS/GROUP DISCUSSIONS:

- Plan and Execute 2-3 group projects in the field of spectroscopy, thin films, nanomaterials and crystallography, if, possible where advanced facilities are available
- Organize workshops/seminars on experimental physics inviting experts
- Undertake cleaning and servicing of laboratory apparatus
- Organize quiz competition for undergraduate students

PEDAGOGY STRATEGIES:

- Laboratory
- Powerpoint presentations
- Assignments
- Seminars
- Group discussions
- Quizes

REFERENCES:

1. S.P Singh, Advanced Practical Physics, Pragati Prakasan,
2. Gupta, Kumar, Practical Physics, Pragati Prakasan
3. D. Chattopadhayay, C.R Rakshit, An Advanced Course in Practical Physics, New Central Book Agency Pvt. Ltd

FURTHER READING:

1. B.L Worsnop and H.T Flint, Advanced Practical Physics for Students, University of California
2. Chauhan, Singh, Advanced Practical Physics, Pragati Prakashan
3. D. Malacara (ed), Methods of Experimental Physics, Series of Volumes, Academic Press Inc.
4. R.A. Dunlap, Experimental Physics: Modern Methods, Oxford University Press.

5. D.R. Behekar, Dr. S. T. Seman, V.M. Gokhale, P.G .Kale, Practical Physics, (Kitab Mahal Publication)

WEB-RESOURCES:

1. https://www.youtube.com/playlist?list=PLbRMhDVUMngcHCX4U7syOHOmnMW7f3Z2g
2. https://www.youtube.com/playlist?list=PLbRMhDVUMngcntq74GxOcIINQGDyApYLX
3. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.727.202&rep=rep1&type=pdf
4. https://www.electronics-tutorials.ws/diode/diode_3.html
5. https://www.mathworks.com/products/matlab-online.htm
6. https://www.coursera.org/learn/matlab

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcomes (CLO)						
	1	2	3	4	5	6	7
Disciplinary Knowledge	✓		✓	✓	✓	✓	
Communication Skills				✓			
Critical Thinking	✓	✓	✓		✓	✓	
Research-related skills	✓	✓		✓		✓	
Analytical reasoning	✓	✓	✓	✓		✓	
Problem Solving	✓	✓	✓			✓	
Team work				✓		✓	
Moral and ethical awareness					✓		✓
Multicultural Competence							✓

Year	Subject Title	Sem	Sub Code	Hours/ Week
2021-22 Onwards	**PRACTICAL-IV: ELECTRONICS, MICROPROCESSOR AND C++ PROGRAMMING (Examination at the end of IV Semester) (Any 12)**	**IV**	**21MPH46P**	**6**

COURSE LEARNING OUTCOME:

On the successful completion of the course, students will be able to

CLO-1 Design and study the various Op. Amp characteristics.
CLO-2 Define the primary functions of 8085 ALP and basic principles of C++ programming.
CLO-3 Account of theoretical concepts and their physical significance.
CLO-4 Apply the theory to find the solutions of practical problems.
CLO-5 Analyze the problem studied through analytical calculation.
CLO-6 Appreciate the problem solving skills and to create more problems.
CLO-7 Develop the applications using object oriented programming with C++

PRACTICALS :

1. Design and study of Wien Bridge Oscillator using Op. Amp.
2. Design and study of Phase shift Oscillator using Op. Amp
3. Solution of differential equation using Op. Amp
4. Solution of simultaneous equations using Op. Amp
5. Op-amp as logarithmic and antilogarithmic amplifier
6. Design of MOD 3 and MOD 5 counters using JK flip-flop
7. Design of MOD 10 counter using JK flip-flop
8. Binary adder and subtractor using 7483 and 7486
9. Design of self-correcting ring counter
10. Three bit binary Up/Down counter using IC 7473
11. 8085 ALP for addition, subtraction, multiplication and division
12. 8085 ALP for subtraction using 1’s and 2’s complement methods
13. 8085 ALP for finding the largest/smallest number in an array and sum of a finite series
14. 8085 ALP for sorting the array in ascending and descending order
15. 8085 ALP for BCD to binary and binary to BCD
16. Waveform generation using 8085
17. LED interfacing using 8085
18. Traffic light controller using 8085
19. Stepper motor controller using 8085
20. Digital clock using 8085
21. C++ Program to fit a straight line y = ax + b using method of least squares
22. C++ Program to solve nonlinear equations using Newton- Raphson method

23. C++ Program to solve system of linear equations using Newton- Raphson method
24. C++ Program to evaluate the integral using (1) Trapezoidal rule (2) Simpson's 1/3rd rule
25. C++ Program to solve the first order differential equation using Runge-Kutta method

PEDAGOGY STRATEGIES:

- Laboratory classes
- Assignments
- Model test

REFERENCES:

1. Basic Electronics (Solid State) by B.L. Theraja, S. Chand & Co. Ltd. (Unit 5)
2. Op.Amp and linear integrated circuits; Ramakant A.Gayakwad
3. Microprocessor Architecture, programming and applications – Ramesh P Gaonkar – Penram publishing house – fifth edition
4. Object Oriented Programming with C++by E.balagurusamy, TMH,2nd edition,2011

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES							
	Course Level Outcomes (CLO)						
	1	2	3	4	5	6	7
Disciplinary Knowledge	✓	✓	✓	✓			
Communication Skills					✓	✓	✓
Critical Thinking	✓		✓	✓		✓	
Research-related skills	✓	✓	✓				✓
Analytical reasoning	✓	✓		✓	✓	✓	✓
Problem Solving	✓	✓	✓	✓	✓	✓	
Team work		✓					✓

7. Teaching Learning Methodologies

The learning outcomes-based course curriculum framework of Chemistry is designed to persuade the subject specific knowledge as well as relevant understanding of the course. The academic and professional skills required for Physics-based professions and jobs are also offered by same course in an extraordinary way. In addition, the learning experiences gained from this course should be designed and implemented for cognitive development in every student. The practical associated with this course helps to develop an important aspect of the teaching-learning process. Various types of teaching and learning processes will need to be adopted to achieve the same. The important relevant teaching and learning processes involved in this course are;

a. Class lectures
b. Seminars
c. Tutorials
d. Group discussions and Workshops
e. Peer teaching and learning
f. Question preparation
g. Subjective type
h. Long answer
i. Short answer
j. Objective type
    - Multiple choice questions
    - One answer/two answer type questions
    - Assertion and reasoning

k. Practical and project-based learning

l. Field-based learning

m. Substantial laboratory-based practical component and experiments

n. Open-ended project work,

o. Games

p. Technology-enabled learning

q. Internship in industry, and research establishments.

The effective teaching strategies will also need to be adopted to develop problem-solving skills, higher-order skills of reasoning and analysis. The designed course also encourages fostering the social values/responsibility for maintaining and protecting the surrounding nvironment for improved living conditions. A learner centric and active participatory pedagogy shall be introduced in this framework.

8. Assessment Methods

Academic performance in various courses i.e. core, discipline electives, generic electives and skill enhancement courses are to be considered as parameters for assessing the achievement of students in Chemistry. A number of appropriate assessment methods of Chemistry will be used to determine the extent to which students demonstrate desired learning outcomes. Following assessment methodology should be adopted;

- The oral and written examinations (Scheduled and surprise tests),
- Closed-book and open-book tests,
- Problem-solving exercises,
- Practical assignments and laboratory reports,
- Observation of practical skills,
- Individual and group project reports,
- Efficient delivery using seminar presentations,
- Viva voce interviews are majorly adopted assessment methods for this curriculum.
- The computerized adaptive testing, literature surveys and evaluations, peers and self-assessment, outputs form individual and collaborators.

MODEL QUESTION PAPER

. **GOVERNMENT ARTS COLLEGE (AUTONOMOUS), COIMBATORE**

Q.P. Code: 21MPH12C **Reg.No:**

M.Sc. DEGREE EXAMINATIONS – NOVEMBER 2021
SEMESTER – I PHYSICS
QUANTUM MECHANICS - I

TIME: 2 Hours **Max. Marks: 50**

PART – A (Answer ALL questions)

I. Choose the best answer (5 X 1 = 5)

1. An operator representing observable dynamical variable has ________ value (a) always 0 (b) infinite (c) real (d) imaginary

2. The wave function of the particle in a box lies in which region? a) x > 0 b) x < 0 c) 0 < X < L d) x > L

3. Angular momentum is_________
(a) a scalar (b) a vector directed along the radius (c) a vector directed along the axis of rotation(d)a vector perpendicular to the axis of rotation.

4. Perturbation thory is a systematic procedure for obtaining

(a)exact solution to the unperturbed problem (b)exact solution to the perturbed problem (c)approximate solution to the perturbed problem (d)approximate solution to the unperturbed problem.

5. The nonexistence of the He_2 molecule is a consequence of
(a) the decrease in total energy of two bonded He atoms relative to two isolated He atoms (b) the large ionization energy of helium (c) the repulsive electrostatic force between two electrons of opposite spin (d) the Pauli exclusion principle.

II. Answer any three questions. (3x2=6)

(Answers not exceeding 25 words each)

6. State any two postulates of quantum mechanics.
7. What is a rigid rotator?
8. Define orbital angular momentum.
9. What is the basic principle of WKB method?
10. What are indistinguishable particles?

PART – B (5 X 3 = 15)

(Answers not exceeding 100 words each)

(Answer ALL questions)

11. (a) What is Hilbert space?

(or)

(b) Show that the eigen values of Hermitian operator are real.

12. (a) Explain tunneling through a barrier.

(or)

(b) Write the Schrodinger equation for a particle in a box. Obtain its eigen functions

13. (a) If Jx,Jy,Jz are total angular momentum operators show that $[J_x, J_y] = i\hbar J_z$

(or)

(b) Mention the eigen values of J^2 and J_z

14. (a) Explain the first order Stark effect in the ground state of hydrogen atom.

(or)

(b) Write short notes on variation method.

15. (a) Elucidate Pauli principle.

(or)

(b) Discuss about central field approximation.

PART – C (3 X 8 = 24)

(Answer any THREE questions not exceeding 750 words each)

16. Explain in detail how state vectors and operators are represented in Heisenberg representation.

17. Establish Schrodinger equation for a linear harmonic oscillator and solve it to obtain eigen values and eigen functions.

18. Evaluate C.G. coefficients for $j_1 = 1$ and $j_2 = 1/2$.

19. Summarize the time independent perturbation theory for degenerate case in first and second orders.

20. Explain Thomas-Fermi model of the atom.