1.1.2

Supporting Documents-

Department of Physical Sciences

Approved Minutes of BOS Meeting(s)

I.K. Gujral Punjab Technical University, Kapurthala

Department of Physical Sciences

Minutes of Meeting

Ref No. IKGPTU/PS/171 **Date: 17.09.2021**

A meeting of members of Board of Studies (BoS)-Physical Sciences, Nano Science and Engineering, IKGPTU was held on 16.09.2021 in the Department of Physical Sciences, I K Gujral Punjab Technical University, Kapurthala via online mode.

Following members of BoS were present and actively participated in discussion:

1. Dr. Hitesh Sharma (Chairperson)
2. Dr. Amit Sarin, Member
3. Dr. Kanchan L. Singh, Member
4. Dr. Anupamdeep Sharma, Member
5. Dr. B.C. Chaudhary, Member
6. Dr. Harleen Dahiya, Member
7. Dr. H. M. Mittal, Member
8. Dr. Monika Randhawa
9. Dr. Munish Aggarwal, Member
10. Dr. Maninder Kaur, Member
11. Dr. Varinderjit Singh, Member
12. Dr. Neetika (coordinator)
13. Ms. Nikita Thakur, M.Sc. (2nd Year) -Student representative
14. Ms. Gurmeet Kaur, M.Sc. (2nd Year) -Student representative

Following members could not attend the meeting:

1. Dr Rakesh Dogra, Member
2. Dr A. K. Tyagi, Member

The Board of Studies discussed on all the agenda points and following recommendations were made:

Agenda 7.1 ***To consider the Program outcomes (POs) and Course outcomes (COs) of Pre-Ph.D. course work***

All BoS members discussed the Program outcomes (POs) and Course outcomes (COs) of the Pre-PhD course work. After incorporating suggestions, BOS members recommended the Program outcomes (POs) and Course outcomes (COs) of various subjects Pre-PhD course for approval w.e.f. 2021 academic session.

The copy of revised Program outcomes (POs), and Course outcomes (COs) of Pre-Ph.D. course work is enclosed as Annexure-I.

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Solids (BTPH-101-18) were carried out, and a unit on introduction to Quantum mechanics is added in Semiconductor Physics (BTPH-104-18) and Semiconductor and Opto-electronics Physics (BTPH-105-18). The title of course on "Introduction to Physics: Biotechnology" (BTPH-107-18) is changed to the Introduction to Modern Physics. Further, the list of experiments is also updated in all the Lab courses.

All the BoS members recommended that the following courses may be revised. List of theory courses with new codes

- **Mechanics of Solids (BTPH-101-21)**
- **Semiconductor Physics (BTPH-104-21)**
- **Semiconductor and Opto-electronics Physics (BTPH-105-21)**
- **Introduction to Modern Physics (BTPH-105-21)**

List of Lab courses with new codes

- **Mechanics of Solids Lab (BTPH-111-21)**
- **Optics and Modern Physics Lab (BTPH 112-21)**
- **Electromagnetism Lab (BTPH-113-21)**
- **Semiconductor Physics Lab (BTPH-114-21)**
- **Semiconductor and Opto-electronics Physics (BTPH-115-21)**
- **Optics and Electromagnetism Lab (BTPH116-21)**
- **Physics Lab (BTPH-117-21)**

The copy of updated syllabi and course codes of B. Tech. first year courses are attached here as Annexure-IV.

Table Agenda 7.6 ***Regarding preparation of syllabus of Bridge Courses of Physical Sciences.***

The University has received the Punjab Govt. Notification No. TECH-TE-2013/4/2021-4TE2/1/229119/2021 and No.TECH-TE-2013/4/2021-4TE2/1/229120/2021 dated 13.08.2021, in which the Punjab Govt. has notified the criteria of B.Tech. 1st year and LEET Students admission (copies of notification are attached as Annexure IX). The relevant portion is as under:-

All those candidates who have passed the 10+2 examination from a board recognized or established by central/state government through a legislation and a member of Council of Boards of School Education (COBSE), New Delhi with Physics/Mathematics/Chemistry/Computer Science/Electronics/ Information Technology/Biology/Informatics Practices/ Biotechnology /Technical Vocational Subject /Agriculture/ Engineering Graphics / Business Studies / Entrepreneurship. (any of three)

Obtained atleast 45% marks (40% marks in case of candidates belonging to reserved category) in the above subject taken together.

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OR

Those candidates who have passed diploma in any Engineering Trade from Punjab State Board of Technical Education & Industrial Training, Chandigarh or Sant Longowal Institute of Engineering and Technology, Longowal (SLIET), or any such examination from any other recognized State Board of Technical Education with at least 45% marks (40% marks in case of candidates belonging to reserved category)

(The Universities will offer suitable bridge courses such as Mathematics, Physics, Engineering drawing, etc., for the students coming from diverse backgrounds to achieve desired learning outcomes of the programme)

OR

The candidates who have passed two years certificate course from Sant Longowal Institute of Engineering and Technology, Longowal (SLIET) shall be eligible.

Therefore, syllabus for bridge course for Physical Sciences is required to be prepared by BoS.

All BoS members discussed the content of lecture-based module for Bridge course in Physics proposed by AICTE. The bridge course comprising of nine modules in Classical Mechanics, Mechanical Properties of Solids and Fluids, Waves and Oscillations, Electricity and Magnetism, Electromagnetic Signal, Wave Optics, Semiconductor Electronics, Modern Physics, Atomic and Nuclear Physics prescribed by AICTE. Copy of syllabus is attached here as Annexure V.

BoS members recommended that lecture based module of Bridge course in physics comprising of 9 modules (22 hrs) proposed by the AICTE may be adopted for all non-physics background students. Copy of syllabus is attached here as Annexure V.

17/09/2021

Dr Hitesh Sharma
Chairperson-BoS (Physical Sciences, Nanoscience and Engineering)

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Annexure-I

Pre-Ph.D.

Course Structure and Syllabus
(Based on Choice Based Credit System)
2021 onwards

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Pre-PhD. Program

PROGRAM OUTCOMES: At the end of the program, the student will be able to:

PO1	Apply the scientific knowledge to solve the complex physics research problems.
PO2	Identify, formulate, and analyze advanced scientific problems reaching substantiated conclusions using first principles of physics, physical, and natural sciences.
PO3	Design solutions for advanced scientific problems and design system components or processes that meet the specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal consideration.
PO4	Use research-based knowledge and methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	Create, select, and apply appropriate techniques, resources, and modern scientific tools to complex physics problems with an understanding of the limitations.
PO6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues, and the consequent responsibilities relevant to the professional scientific practice.
PO7	Understand the impact of the scientific solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	Apply ethical principles and commit to the norms of scientific practice.
PO9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	Communicate effectively on scientific activities with the Scientific/Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	Demonstrate knowledge and understanding of the scientific principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of scientific and technological change.

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SCHEME OF Pre-Ph.D. COURSE WORK

Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Credits
		L	T	P	Internal	External		
PHS900	Research Methodology	3	1	-	40	60	100	4
PHS901	Theoretical methods in Physics	3	1	-	40	60	100	4
PHS902	Techniques in Experimental Physics	3	1	-	40	60	100	4
PHS903	Advanced Condensed Matter Physics	3	1	-	40	60	100	4
PHS904	Computational Physics	3	1	-	40	60	100	4
PHS905	Nano Materials	3	1	-	40	60	100	4
PHS906	Advanced Particle Physics	3	1	-	40	60	100	4
PHS907	Renewable Energy Resources	3	1	-	40	60	100	4

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CORE COURSE

PHS 900	**Research Methodology**	**L-3, T-1, P-0**	**4 Credits**

Pre-requisite: Understanding of post graduate level physics

Course Objectives: The objective of the course on **Research methodology** is to equip the Ph.D. students with the research methodologies and techniques that he/she needs for understanding theoretical treatment in different courses and for developing a strong background if he/she chooses to pursue research in physics as a career.

Course Outcomes: At the end of the course, the student will be able to

CO1	understand the need for research and basic objective of research.
CO2	work with different types of documents, organize them into different sections, subsections, implicate various formatting types and write complex mathematical formulae.
CO3	handle data, plot graphs, draw flow charts, survey research related problems and infer data using any plotting softwares.
CO4	understand the methods used for estimating and dealing with experimental uncertainties and systematic "errors".
CO5	identify and define appropriate research problem and document a research paper, thesis, or a research proposal using the scientific documentation tools.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	1	2	2	1	1	2
CO2	3	3	2	1	2	1	1	2	2	1	1	2
CO3	3	3	2	2	2	1	1	2	2	1	1	2
CO4	3	3	2	2	2	1	1	2	2	1	1	2
CO5	3	3	2	2	2	1	3	3	3	3	3	3

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Detailed Syllabus:

1. Introduction to Research. Objectives of research, motivation in research, types of research, significance of research, research methods vs methodology, research process in flow chart, criteria of good research, problems encountered by researchers in India.

2. Difference between TEX and LATEX. basics of using latex, latex input files, input file structures, layout of the document, titles, chapter and sections, cross references, foot note, environments, typesetting building blocks of a mathematical formula, matrices, tables, including encapsulated postscript graphics, bibliography, downloading and installing LATEX packages.

3. Introduction to origin, basics of importing and exporting data, working with Microsoft excel, graphing, statistics in origin, hypothesis testing power and sample size, basic linear regression and curve fitting.

4. Error Analysis and Basic Statistics: Measuring errors, uncertainties, parent and sample distributions, mean and standard deviation of distribution, types of probability distribution, instrumental and statistical uncertainties, propagation of errors, specific error formulas, method of least square fittings.

5. Multivariate analysis: Multiple regression, multiple discriminant analysis, multiple analysis of variance, canonical correlation analysis, Factor analysis cluster analysis, path analysis. Computational techniques.

6. Survey of literature: The students will be required to review literature in their respective disciplines and submit an assignment for evaluation.

Text Books:

1. Michael P. Marde. "Research Methods for Science", Cambridge University Press, 2011.
2. Tobian Oetiker, Hubert Partl, Hrene Hyna and Elisabeth Schlegl, "The not so short introduction to LATEX"
3. T. Veerarajan and T. Ramachandran "Numerical methods", Tata McGraw Hill, New Delhi, 2008.
4. Philip R. Bevington and D. Keith Robinson, "Data reduction and error analysis for physical sciences" McGraw-Hill Education, 2002.

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Core: Subject Related Theory Paper

PHS 901	Theoretical methods in Physics	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of post graduate level physics

Course Objectives: The objective of the course on **Theoretical methods in Physics** is to equip the Ph.D. students with the mathematical techniques that he/she needs for understanding theoretical treatment in different research problems and for developing a strong background if he/she chooses to pursue research in physics as a career.

Course Outcomes: At the end of the course, the student will be able to

CO1	understand various theoretical methods used in advance courses in physics now a days.
CO2	understand NMR and other related techniques and density functional theory.
CO3	understand and solve the Kohn-Sham equations and theorems in condensed matter physics.
CO4	understand the elementary particle physics, their interactions, and relativistic kinematics.
CO5	analyze and solve various nuclear structure based models.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	1	2	2	1	1	2
CO2	3	3	2	1	2	1	1	2	2	1	1	2
CO3	3	3	2	2	2	1	1	2	2	1	1	2
CO4	3	3	2	2	2	1	1	2	2	1	1	2
CO5	3	3	2	2	3	1	3	3	3	3	3	3

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Detailed Syllabus:

1. Theoretical Techniques in Condensed Matter Physics: Theory of NMR techniques, Theory of Anharmonic solids, Theory of Liquid state.

2. Advanced Quantum Techniques: Review of electronic properties, Density Functional Theory, Hohenberg- Kohn theorems, Kohn-Sham ansatz, Intricacies for exchange & correlation, Solving Kohn-Sham equations, Norm conserving pseudopotentials, Unscreening and core corrections, Transferability and hardness of pseudopotentials.

3. Theoretical Techniques in Particle Physics: Classification of fundamental forces; Elementary particles (quarks, baryons, mesons, leptons); Spin and parity assignments, isospin, strangeness; Gell-Mann-Nishijima formula; C, P, and T invariance and applications of symmetry arguments to particle reactions, party, non-conservation in weak interaction; Relativistic kinematics

4. Theoretical Techniques in Nuclear Physics: Review of static properties, binding energy, density, nuclear forces, and potentials, shell model, collective models and energy levels, Hartree - Fock theory of nuclear shape and states with good J Quantum number and applications, correlations in nuclear matter and exclusive principle correlations, Bethe- Goldstone equation and G-matrix, heavy-ion physics at low and intermediate energies, simulations and QMD model, hot and dense matter and multi fragmentation.

Text Books:

1. Solitons an Introduction by P.G. Drazin and R.S. Johan, Cambridge Univ. Press, 1989.
2. Chaos in Dynamical Systems by E. Ott, Cambridge Univ., Press, 1993.
3. Gauge theory of Elementary Particles by T.P. Cheng and Li, Oxford university press, 2000.
4. Structure of the Nucleus by M.A. Preston and R.K Bhadhuri, CRC Press, 1993.
5. Quantum Theory of Solids by C. Kittel, Wiley 2nd edition, 1987.
6. Liquid State Physics by N.H. March and M.P. Tosi, World Scientific, 2002.
7. Quantum field theory by Lahiri and Pal, Narosa Publishing house, 2007.

PHS 902	Techniques in Experimental Physics	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of post graduate level physics

Course Objectives: The objective of the course on **Techniques in Experimental Physics** is to equip the Ph.D. students with the experimental techniques that he/she needs for understanding experimental aspects of the subject.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand various experimental techniques such as optical microscopy, thermal, surface and electron microscopy used in condensed matter and nano-technology based research areas.
CO2	Use the implications of statistical error analysis for experimental data.
CO3	Know about the different types of the radiation detectors and spectroscopy for radiation analysis while probing nuclear structure.
CO4	Equipped with the basic knowledge about the spectroscopic experimental methods used in the various laboratories across the world.
CO5	Apply the knowledge of X ray diffraction in X-ray fluorescence and understand the spectroscopic analysis of atom/molecules.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	1	2	2	1	1	2
CO2	3	3	2	1	2	1	1	2	2	1	1	2
CO3	3	3	2	2	2	1	1	2	2	1	1	2
CO4	3	3	2	2	2	1	1	2	2	1	1	2
CO5	3	3	2	2	3	1	3	3	3	3	3	3

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Detailed Syllabus:

1. Light/Optical Microscopy: Optical Microscope — basic principles & components, different examination modes (bright field illumination, oblique illumination, dark field illumination, phase contrast, polarized light, hot stage, interference techniques), stereomicroscopy, photo-microscopy.
2. Surface Analysis: Atomic *force* microscopy, Scanning Tunneling microscopy, Secondary ion mass spectrometry, Auger electron spectroscopy, X-ray photoelectron spectroscopy, image analysis.
3. Thermal Analysis: Differential thermal analysis, Differential scanning calorimetry and Thermo-gravimetric analysis. Fourier transform infrared spectroscopy. Ultraviolet visible spectrophotometer.
4. Electron Microscopy: Interaction of electrons with solids. Scanning Electron Microscopy and specimen preparation techniques, Wavelength dispersive spectroscopy.
5. Diffraction Methods: Generation and detection of X-rays. Diffraction of X-rays. X-ray diffraction techniques, X-ray methods of analysis including powder diffraction, Wavelength and energy dispersive X-ray fluorescence (XRF).
6. Radiation analysis: Raman analysis and spectroscopy, Photo luminance, Photo multiplier tube, Experimental methods for probing nuclear structure: Experimental methods for gamma-ray, conversion-electron and charged-particle spectroscopy associated with nuclear reactions and Coulomb excitation, Compton suppressed Ge detectors, multiplicity filter, Neutron detectors, Sector field electron spectrometer.

Text Books:

1. Materials Characterization, Metals Hand Book, 9th edition, Vol 10,1986.
2. Cullity, B.D., "Elements of X-ray Difraction", Addison Wesley Publishing Co., Massachusetts. 1968.
3. Phillips, V.A., "Modern metallographic techniques and their applications", Wiley Interscience, 1971.
4. Cherepin and Malik, "Experimental Techniques in Physical Metallurgy", Asia PublishingCo. Bombay, 1968.
5. Brandon D.G., "Modern Techniques in Metallography", Von Nostrand Inc. NJ. USA, 1986.
6. Thomas G., "Transmission electron microscopy of metals", John Wiley, 1996.
7. Weinberg F., "Tools and Techniques in Physical Metallurgy", Volume I & II, Marcel and Decker, 1970.

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PHS 903	Advanced Condensed Matter Physics	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of post graduate level physics

Course Objectives: The objective of the course on **Advanced Condensed Matter Physics** is to equip the Ph.D. students with the techniques in Transport, optical properties in Mesoscopic Systems, lattice vibrations, dielectric properties, energy band theory and transport theory so that they are equipped with the techniques used in investigating these aspects of the matter in condensed phase.

Course Outcomes: At the end of the course, the student will be able to

CO1	Comprehend and describe the Optical properties of solids employing macroscopic theories
CO2	Explain various types of magnetic phenomenon in solids, underlying physics, and correlation and applications.
CO3	Understand and realize the use of defects and dislocations
CO4	Interpret the phenomena, behavior and applications of materials at the nanoscale
CO5	Figure out and perceive the effect of deformation and disorder on the behavior of solids

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	1	2	2	1	1	2
CO2	3	3	2	1	2	1	1	2	2	1	1	2
CO3	3	3	2	2	2	1	1	2	2	1	1	2
CO4	3	3	2	2	2	1	1	2	2	1	1	2
CO5	3	3	2	2	3	1	3	3	3	3	3	3

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Detailed Syllabus:

1. Transport Properties: Boltzmann equations, Electrical Conductivity, Calculation of relaxation time, Impurity scattering, Ideal resistance, Carrier mobility, General Transport coefficients, Thermal conductivity, Thermoelectric effects, Lattice conduction, Phonon drag, Hall effect, Two Band Model- Magneto resistance.

2. Mesoscopic Systems: Low-dimensional systems; characteristic lengths; transverse mode or magneto-electric sub-bands; resistance of a ballistic conductor; Landauer formula; reformulation of Ohm's law; Landauer-Buttiker formula; transmission function and S-conductance fluctuations.

3. Quantum Hall Effect: Classical Hall effect; integral quantum Hall effect (IQHE); fractional quantum Hall effect (FQHE) and Laughlin's theory.

4. Material at Nanoscale: Synthesis and Fabrication methods (Physical and chemical approaches), characterization methods (microscopy, diffraction, spectroscopy techniques), surface analysis and depth profiling, techniques for physical property measurement, processing and properties of inorganic nanomaterials, special nanomaterials, Thermodynamics and statistical mechanics of small systems, Nucleation and growth of nanocrystals; kinetics of phase transformations. Effects of nanometer length scales, self assembling nanostructures molecular materials and devices, applications of nanomaterials: molecular electronics and nanoelectronics; nano-biotechnology; quantum devices; nanomagnetic materials and devices: magnetism, nanomagnetic materials, magnetoresistance; nano mechanics.

5. Defects and Dislocation: Lattice Vacancies, Diffusions, Color- Centers, Dislocations and their types, Strength of Alloys, Dislocation and crystal growth, Hardness of materials.

Recommended Books:

1. Introduction to Solid State Physics : C. Kittel (Wiley, New York) 2005.
2. Quantum Theory of Solids : C. Kittel (Wiley, New York) 1987.
3. Principles of the Theory of Solids : J. Ziman (Cambridge University Press) 1972.

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PHS 904	Computational Physics	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of post graduate level physics

Course Objectives: The aim and objective of the course on **Computational Physics** is to familiarize the students of Ph.D. students with the numerical methods used in computation and programming using any high level language such as Fortran, C++, etc., so that they can use these in solving simple physics problems.

Course Outcomes: At the end of the course, the student will be able to

CO1	Apply basics knowledge of computational physics in solving the physics problems.
CO2	Program with the C++ or any other high level language.
CO3	Use various numerical methods in solving research level problems in his area of interest.
CO4	Analyze the outcome of the algorithm/program graphically.
CO5	Simulate the physical systems using simulation based approaches.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	2	2	2	2	1	1	2
CO2	3	3	2	1	2	1	2	2	2	1	1	2
CO3	3	3	2	2	2	1	1	2	2	1	1	2
CO4	3	3	2	2	2	1	1	2	2	1	1	2
CO5	3	3	2	2	3	1	3	3	3	3	3	3

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Detailed Syllabus:

1. Introduction to simulation approach: Introduction to modeling and simulation Methods of performance evaluation-simulation approach- Advantages and limitations, various type models and simulations, System model steps and its types involved in simulation study, Deterministic and Stochastic process, Introduction to random variables - univariate models and multi-narrate models.

2. Numerical methods for differential equations: Euler's method, Runge - Kutta method for ordinary differential equations: stability and convergence. Partial differential equations using matrix method for difference equation, relaxation method, initial value problems, stability, convergence and qualitative properties and qualitative properties. Random numbers, Monte Carlo Integral methods, Importance sampling, Fast Fourier Transform.

3. Simulation Techniques: Monte Carlo methods, molecular dynamics, simulation methods for the Ising model and atomic fluids, simulation methods for quantum-mechanical problems, time-dependent Schrodinger equation, discussion of selected problems in Physics, nonlinear dynamics, diffusion-limited aggregation and transport properties, etc. Introduction to parallel computation, Physical Simulations: N body methods and particle simulations.

4. Introduction to graphical analysis: Introduction to Gnuplot, importance of visualization of computational data, Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot

Text Books:

1. Fortran Programming, V. Rajaraman, Prentice Hall India Learning Private Limited, 1997.
2. Numerical Methods: A Computer Oriented Approach, BPB Publ. 1996.
3. R.S. Salaria and Rajaraman, Computer based Numerical Methods 3rd Ed. Prentice Hall India, 1980.
4. Mathematica, S. Wolfram, Addison Wesley, 2003.
5. Application of the Monte Carlo Method, K. Binder, Springer-Verlag, 1987.
6. An Introduction to Computer Simulation Methods, H.Gould and J. Toobochnlik, Addison Wesley, 1996.
7. Computational Physics, S.E. Koonin and Meredith, Westview Press, 1998.
8. Gnuplot in Action: Understanding Data with Graphs, Philipp K. Janert, Manning Publications (2016)

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PHS 905	Nano Physics	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of post graduate level condensed matter physics

Course Objectives: The objective of the course on Nano materials is to equip the Ph.D. students with the mathematical and experimental techniques that he/she needs for understanding the condensed matter physics and pursue research career in nano materials research.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand and familiarize with synthesis and processing techniques of Nano particles.
CO2	Understand the electrical and magnetic properties of quantized states in low-dimension systems.
CO3	Describe the use of unique optical properties of nanoscale metallic structures for analytical physical, chemical, and biological applications.
CO4	Understand the physical and chemical properties of carbon nanotubes and nanostructured mesoporous materials.
CO5	Determine the structure-property relationships in nanomaterials as well as the concepts, not applicable at larger length scales.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	1	2	2	1	1	2
CO2	3	3	2	1	2	1	1	1	2	1	1	2
CO3	3	3	2	2	2	1	1	1	2	1	1	2
CO4	3	3	2	2	2	1	1	2	2	1	1	2
CO5	3	3	2	2	3	1	3	3	3	3	3	3

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4. Optical properties: Photo refractive quantum well structures and its optical properties, electronic transport and grating formation, Diffraction-Raman N diffraction; nondegenerate four-wave mixing two- wave mixing, Photorefractive effects and applications, Non-linear optical properties, Non-linear phenomenon - theoretical treatment of optical on linearities.

Text Books:

1. Nalwa HS. "Handbook of Nanostructured Materials and Nanotechnology", Vol.1, 3 and 4 Academic Press 2000.
2. Ying J.Y. 'Nanostructured materials" Academic Press, U.S.A ,2001.

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PHS907	Renewable Energy Resources	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of semiconductor physics

Course Objectives: The aim and objective of the course on **Renewable Energy Resources** is to expose the Ph.D. students to the basics of the alternative energy sources like solar energy, hydrogen energy, etc.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the energy demand of world & distinguish between traditional and alternative form of energy.
CO2	Describe the concept of solar energy radiation and thermal applications.
CO3	Analyze making of solar cell and its types.
CO4	Identify hydrogen as energy source, its storage and transportation methods.
CO5	Compare wind energy, wave energy and ocean thermal energy conversion.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	1	1	2	1	1	2
CO2	3	3	2	1	2	1	1	1	2	1	1	2
CO3	3	3	2	2	2	1	1	1	2	1	1	2
CO4	3	3	2	2	2	1	1	1	2	1	1	2
CO5	3	3	2	2	2	1	3	1	3	3	3	3

Detailed Syllabus:

1. **Introduction**: Production and reserves of energy sources in the world and in India, need for alternatives, renewable energy sources. *(Lectures 8)*

2. **Solar Energy**: Thermal applications, solar radiation outside the earth's atmosphere and at the earth's surface, Principal of working of solar cell, Performance characteristics of solar cell. Types of solar cell, crystalline silicon solar cell, Thin film solar cell, multijunction solar cell, Elementary ideas of perovskite solar cell, dye synthesized solar cell and Tandem solar cell, PV solar cell, module array, and panel, Applications. *(Lectures 11)*

3. **Hydrogen Energy**: Environmental considerations, solar hydrogen through photo electrolysis and photocatalytic process, physics of material characteristics for production of solar hydrogen. Storage processes, solid state hydrogen storage materials, structural and electronic properties of storage materials, new storage modes, safety factors, use of hydrogen as fuel; use in vehicles and electric generation, fuel cells. *(Lectures 10)*

Annexure-II

B.Sc. (Hons.) Physics

Course Structure and Syllabus
(Based on Choice Based Credit System)
2021 onwards

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PROGRAM EDUCATIONAL OBJECTIVES: At the end of the program, the student will be able to:

PEO1	Apply principles of basic science concepts in understanding, analysis and prediction of physical systems.
PEO2	Develop human resource with knowledge, abilities and insight in Physics and related fields required for career in academia and industry.
PEO3	Engage in lifelong learning and adapt to changing professional and societal needs.

PROGRAM OUTCOMES: At the end of the program, the student will be able to:

PO1	Apply the knowledge gained to solve the scientific problems.
PO2	Identify, formulate, and analyze scientific problems reaching substantiated conclusions using first principles of mathematical, physical, and chemical sciences.
PO3	Design solutions for physics problems that meet the specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal consideration.
PO4	Use research-based knowledge and methods including design of experiments, analysis, interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	Create, select, and apply appropriate techniques, resources, and modern scientific tools to physics problems with an understanding of the limitations.
PO6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues, and the consequent responsibilities relevant to the professional scientific practice.
PO7	Understand the impact of the scientific solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	Apply ethical principles and commit to the norms of scientific practice.
PO9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	Communicate effectively on scientific activities with the Scientific/Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	Demonstrate knowledge and understanding of the scientific principles and apply these to one's own work, as a member and leader in a team, to manage projects and in

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	multidisciplinary environments.
PO12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of scientific and technological change.

PROGRAM SPECIFIC OUTCOMES: At the end of the program, the student will be able to:

PSO1	Understand the concepts of different branches of physics.
PSO2	Demonstrate expertise to conduct wide range of scientific experiments.
PSO3	Apply the concepts of physics in areas of mechanics, electromagnetism, solid state, nuclear, etc., in industry, academia, and day-to-day life.

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SEMESTER FIRST

Course Code	Course Title	Type of course	Load Allocation			Marks Distribution		Total Marks	Cr
			L	T	P	Internal	External		
BSHP-111-21	Optics	Core Course Theory and Practical	3	1	-	40	60	100	4
BSHP-112-21	Mechanics		3	1	-	40	60	100	4
BSHP-113-21	Physics Lab-I		-	-	4	30	20	50	2
BSHM-114-21	Calculus	General Elective and Practical	3	1	-	40	60	100	4
BSHC-112-21	Inorganic Chemistry		3	1	-	40	60	100	4
BSHC-113-21	Chemistry Lab-I		-	-	4	30	20	50	2
BHHH-105-21	Communicative English -I	Ability Enhancement Compulsory Course	2	-	-	20	30	50	2
BSHH-106A-21 BSHH-106B-21	Punjabi Compulsory-I or Mudhli Punjabi-I		2	-	-	20	30	50	2
TOTAL			16	4	8	260	340	600	24

L: Lectures T: Tutorial P: Practical Cr: Credits

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SEMESTER SECOND

Course Code	Course Title	Type of course	Load Allocation			Marks Distribution		Total Marks	Cr
			L	T	P	Internal	External		
BSHP-121-21	Waves and Vibrations	**Core Course Theory and Practical**	3	1	-	40	60	100	4
BSHP-122-21	Electricity and Magnetism		3	1	-	40	60	100	4
BSHP-123-21	Physics Lab-II		-	-	4	30	20	50	2
BSHM-204-21	Mathematics	**General Elective and Practical**	3	1	-	40	60	100	4
BSHC-102-21	Organic Chemistry		3	1	-	40	60	100	4
BSHC-102-21	Chemistry Lab-II		-	-	4	30	20	50	2
BSHH-205-21	Communicative English -II	**Ability Enhancement Compulsory Course**	2	-	-	20	30	50	2
BSHH-206A-21 BSHH-206A-21	Punjabi Compulsory -II or Mudhli Punjabi-II		2	-	-	20	30	50	2
TOTAL			16	4	8	260	340	600	24

L: Lectures T: Tutorial P: Practical Cr: Credits

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Examination and Evaluation

S. No.	Evaluation criteria	Weightage in Marks	Remarks
Theory			
1	Mid term/sessional Tests	24	Internal evaluation (40 Marks)
2	Attendance	6	MSTs, Quizzes, assignments, attendance, etc., constitute internal evaluation. Average of two mid semester test will be considered for evaluation.
3	Assignments	10	
4	End semester examination	60	External evaluation
5	Total	100	Marks may be rounded off to nearest integer.
Practical			
1	Evaluation of practical record/ Viva Voice/Attendance/Seminar/ Presentation	30	Internal evaluation
2	Final Practical Performance + Viva-Voce	20	External evaluation
3	Total	50	Marks may be rounded off to nearest integer.

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Instructions for Paper-Setter in B. Sc (Hons.) Physics

A. Scope

1. The question papers should be prepared strictly in accordance with the prescribed syllabus and pattern of question paper of the University.

2. The question paper should cover the entire syllabus with proper distribution and Weightage of marks for each question.

3. The language of questions should be simple, direct, and documented clearly and unequivocally so that the candidates may have no difficulty in appreciating the scope and purpose of the questions. The length of the expected answer should be specified as far as possible in the question itself.

4. The distribution of marks to each question/answer should be indicated in the question paper properly.

B. Type and difficulty level of question papers

1. Questions should be framed in such a way as to test the students intelligent grasp of broad principles and understanding of the applied aspects of the subject. The Weightage of the marks as per the difficulty level of the question paper shall be as follows:

i)	Easy question	30%
ii)	Average questions	50%
iii)	Difficult questions	20%

2. The numerical content of the question paper should be upto 25%.

C. Format of question paper

1. Paper code and Paper-ID should be mentioned properly.
2. The question paper will consist of three sections: Sections-A, B and C.
3. Section-A is COMPULSORY consisting of TEN SHORT questions carrying two marks each (total 20 marks) covering the entire syllabus.
4. The Section-B consists of FOUR questions of eight marks each covering the entire PART-A of syllabus (Taking two questions from every unit).
5. The Section-C consists of FOUR questions of eight marks each covering the entire PART-B of syllabus (Taking two questions from every unit).
6. Attempt any five questions from Section-B and Section-C, selecting at least two questions from each of the two sections.

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Question paper pattern for MST:

Roll No:	**No of pages:**

IK Gujral Punjab Technical University- Jalandhar	
Department of Physical Sciences	
Academic Session:	
Mid-Semester Test: I/II/III (Regular/reappear)	**Date:**
Programme: B.Sc. (Hons.) Physics	**Semester:**
Course Code:	**Course:**
Maximum Marks: 24	**Time: 1 hour 30 minutes**

❖ Note: Section A is compulsory; Attempt any two questions from Section B and one question from Section C.

Section: A		**Marks**	**COs**
1		2	
2		2	
3		2	
4		2	
Section: B			
5		4	
6		4	
7		4	
Section: C			
8		8	
9		8	

Details of Course Objectives

CO1	
CO2	
CO3	
CO4	
CO5	

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BSHP-113-21	**Physics Lab-I**	**L-0, T-0, P-4**	**2 Credits**
Pre-requisite (If any): High-school education			
Course Objectives: The aim and objective of the lab course is to introduce the students to the formal structure of electromagnetism and phenomenon of wave optics so that they can use these as per their requirement.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Able to verify the theoretical concepts/laws learnt in theory courses.		
CO2	Trained in carrying out precise measurements and handling sensitive equipment.		
CO3	Understand the methods used for estimating and dealing with experimental uncertainties and systematic "errors".		
CO4	Learn to draw conclusions from data and develop skills in experimental design.		
CO5	Document a technical report which communicates scientific information in a clear and concise manner.		

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	2	1	2	3	2	3
CO2	3	3	1	-	2	2	1	1	1	3	2	3
CO3	3	3	2	-	2	1	2	1	1	3	2	3
CO4	3	2	2	2	-	2	2	1	1	3	2	3
CO5	2	2	2	2	-	2	2	1	1	3	2	3

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SEMESTER-I

BSHP-111-21	Optics	L-4, T-0, P-0	4 Credits

Pre-requisite: Understanding of senior secondary level Physics and Mathematics

Course Objectives: The objective of the course is to develop basic understanding of Interference, Diffraction and Polarization among students. They also learn about the LASER and its applications. Students will be equipped with knowledge to measure wavelength, refractive index and other related parameters, which will act as a strong background if he/she chooses to pursue physics as a career.

Course Outcomes: At the end of the course, the student will be able to

CO1	Identify and illustrate physical concepts and terminology used in optics and other related wave phenomena
CO2	Analyze and understand coherence and phenomenon of interference and their applications
CO3	Acquainted with Fresnel's and Fraunhofer's diffraction and their applications.
CO4	Get thorough knowledge of the polarization of light, changes upon reflection and transmission and will learn to analyze the polarization in optical systems.
CO5	Describe the different types of lasers, its principle, properties and applications of laser beam.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	1	-	1	2	1	2	3	2	2
CO2	2	2	1	2	1	1	1	1	1	3	1	1
CO3	3	2	2	2	1	1	2	1	1	3	1	1
CO4	2	2	2	2	1	1	2	1	1	3	1	1
CO5	2	2	2	2	1	1	2	1	1	3	1	1

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Detailed Syllabus:

PART-A

UNIT I

Interference: Definition and properties of wave front, Temporal and Spatial Coherence, Young's double slit experiment, Lloyd's single mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films, Fringes of equal inclination (Haidinger Fringes), Newton's Rings: Measurement of wavelength and refractive index, Interferometer: Michelson Interferometer-(1) idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, Fabry-Perot interferometer. (11 Lectures)

UNIT-II

Diffraction: Huygens Principle, Huygens-Fresnel Diffraction theory, Fraunhofer diffraction: Single slit, Circular aperture, Rayleigh criterion of resolution, Resolving Power of a telescope, Double slit, Multiple slits, Diffraction grating, Resolving power of grating. Fresnel Diffraction: Fresnel's Assumptions, Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light, Theory of a Zone Plate: Multiple Foci of a Zone Plate, Fresnel diffraction pattern of a straight edge and circular aperture. (11 Lectures)

PART-B

UNIT-III

Polarization: Plane polarized light, Representation of Unpolarized and Polarized light, Polarization by Reflection, Brewster's law, Malus Law, Polarization by Selective absorption by Crystals, Polarization by Scattering, Polarization by Double Refraction, Nicol Prism, Huygen's theory of Double Refraction, Polaroid, Elliptically and Circularly polarized lights, Quarter and Half wave plates. (11 Lectures)

UNIT-IV

Laser and Application: Lasers, Spontaneous emission, Stimulated absorption, Stimulated emission, Einstein coefficients, Einstein relations, Conditions for Laser actions, Population inversion, Different types of Laser Pumping mechanism: Optical Pumping, Electric Discharge and Electrical pumping, Resonators, Two, Three and Four level laser systems, Ruby laser, He-Ne gas Laser, Semiconductor laser, CO_2 laser, applications of laser: Holography, Principle of Holography. (11 Lectures)

Text and Reference Books:

1. Optics: A.K. Ghatak (Tata-McGraw Hill), 1992.
2. Fundamentals of Optics: F.A. Jenkins and H.E. White (McGraw Hill), 1981.
3. A Textbook of Optics: Subrahmaniyam N. & et al., S. Chand Publishing, 2006.
4. O. Svelto: Principles of Lasers, Springer Science & Business Media, 2010.

BSHP-112-21	Mechanics	L-4, T-0, P-0	4 Credits

Pre-requisite: Understanding of senior secondary level Physics and Mathematics

Course Objectives: The aim and objective of the course on Mechanics is to introduce the students to the formal structure of vector mechanics, harmonic oscillators, and mechanics of solids so that they can use these in Engineering as per their requirement. This will act as a strong background if he/she chooses to pursue higher studies in physics.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the fundamentals of vector mechanics for a classical system.
CO2	Identify various types of forces in nature, frames of references, and conservation laws.
CO3	Know the inertial and non-inertial system.
CO4	Understand the Gravitation force as a Central Force Motion
CO5	Apply the knowledge obtained in this course to day-to-day problems.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	-	1	2	1	2	1	2	3	2	2
CO2	2	3	1	2	2	1	1	1	1	3	1	1
CO3	3	3	2	2	2	1	2	1	1	3	1	1
CO4	2	2	2	-	2	1	2	1	1	3	1	1
CO5	2	2	-	2	2	1	2	1	1	3	1	1

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Detailed Syllabus:

UNIT I:

Fundamentals of Dynamics: Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. Momentum of variable-mass system: motion of rocket. (12 Lectures)

UNIT II:

Work and Energy: Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Force as gradient of potential energy. Work done by non-conservative forces. Law of conservation of Energy.

Collisions: Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frame of references. (12 Lectures)

UNIT-III

Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems. (12 Lectures)

UNIT-IV

Gravitation and Central Force Motion: Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and fields due to spherical shell and solid sphere. Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). (12 Lectures)

Text and Reference Books:

1. Mechanics, Berkeley Physics, Vol.1,C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
2. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
3. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education
4. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons
5. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
6. Physics for scientists and Engineers with Modern Phys., J.W.Jewett, R.A.Serway, 2010, Cengage Learning
7. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

Note: Students are expected to perform about 8-10 experiments from the following list, selecting minimum of 6-7 from the Physical Lab and 2-3 from the Virtual lab.

List of experiments:

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the laser beam characteristics like; wave length, aperture, spot size, etc. using diffraction grating.
3. To study the diffraction using laser beam and thus to determine the grating element.
4. To study wavelength and laser interference using Michelson's Interferometer.
5. To find the refractive index of a material/glass using spectrometer.
6. To find the refractive index of a liquid using spectrometer.
7. To determine the angle of prism and resolving power of a prism.
8. To study the magnetic field of a circular coil carrying current using a Steward and Gees Tangent Galvanometer.
9. Determine the radius of circular coil using the Circular coil.
10. To study B-H curve using CRO.
11. To find out polarizability of a dielectric substance.
12. To find out the horizontal component of earth's magnetic field (B_h).

Text and Reference Books:

1. A Text -book of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal.
2. Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
3. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.
4. Practical Physics, C L Arora. S. Chand & Company Ltd.
5. http://www.vlab.co.in

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BSHM-104-21	CALCULUS-I	L-4, T-1, P-0	4 Credits

Pre-requisite: Understanding of senior secondary level Mathematics

Course Objectives: The objectives of this course are to make the students understand the following:

1. The fundamental concepts of differential and integral calculus.
2. The geometrical meaning of functions, limits, continuity, derivatives, mean value theorems.
3. Applications of derivatives and integrals.
4. Limit, Continuity, partial derivatives and their applications in finding extreme values.
5. The utility of double and triple integrals in finding area and volume bounded by surfaces.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the basic concepts of Differential and Integral Calculus.
CO2	Visualize all concepts geometrically.
CO3	Apply the knowledge of derivatives in finding extreme values of the function and definite integrals to find area under the curve.
CO4	Explain the concept of Limit, Continuity, partial derivatives of functions of severable variables and their applications.
CO5	Utilize the concept of multiple integrals in finding areas and volumes of different geometrical shapes.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

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Detailed Syllabus:

UNIT-I

Functions of single variable. Simple examples of limit, continuity, differentiability, Derivative of elementary functions (t-ratios, logarithmic functions, exponential functions), Higher order derivatives, Statement of Mean value theorems and simple applications, Applications of derivative: increasing decreasing functions, extreme values of functions. **(Ref. 1)**

UNIT-II

Integration as an inverse process of differentiation. Finding integrals by partial fractions, by parts, Statement of fundamental theorem of calculus, Finding definite integrals by method of substitution, Applications of definite integral in finding length of an arc, area under simple curves, area enclosed between two curves. **(Ref. 1)**

UNIT-III

Introduction of Limit, continuity of functions of two variables with simple examples, partial derivatives, Total derivatives, Homogeneous functions, Statement of Euler's theorem, Simple examples of maxima-minima of functions of several variables, Lagrange's method of multipliers.

UNIT-IV

Double integrals, Change of order of integration, Jacobian, Double integral in polar coordinates, Triple integrals, Simple applications in finding area and volumes.

RECOMMENDED BOOKS:

- Mathematics, A Text book for Class XII (Parts I & II), New Delhi: NCERT, 2003. **(Unit I & II)**
- R.K. Jain and S.R.K. Iyengar, Advanced Engineering Mathematics, Narosa Pub., 4th Edition, 2015.
- James Stewart, Calculus, 5th Edition, Brooks/Cole (Thomson), 2003.

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BHCL-I-102-21	INORGANIC CHEMISTRY	L-4, T-0, P-0	4 Credits

Pre-requisite: Understanding of senior secondary level Physics and Mathematics

Course Objectives: To teach the fundamental concepts of Inorganic chemistry and their applications.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the fundamental concepts and postulates of various theories regarding the structure of atom.
CO2	Learn the periodicity of the s & p block elements
CO3	Understand the various types of bonding present in the different inorganic compounds
CO4	Learn about the various theories pertaining to the different types of boding
CO5	

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

Detailed Syllabus:

PART-A

UNIT-I

Atomic Structure:

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: deBroglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

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UNIT-II

Chemical Bonding-I:

Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.

Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.

UNIT-III

Chemical Bonding-II:

Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

UNIT-IV

Chemistry of s and p Block Elements:

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements. Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate. Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

Reference Books :-

1. Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y. 1994.
3. Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*. Butterworth-Heinemann. 1997.
4. Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.
5. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry 4th Ed.*, Pearson, 2010.
6. Shriver & Atkins, *Inorganic Chemistry 5th Ed.*

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Detailed Syllabus:

PART-A

UNIT I : ਕਵਿਤਾ ਭਾਗ:

ਭਾਈ ਵੀਰ ਸਿੰਘ:

ਸਮਾਂ, ਚਸ਼ਮਾ

ਪ੍ਰੋ. ਪੂਰਨ ਸਿੰਘ :

ਪੰਜਾਬ ਨੂੰ ਕੂਕਾਂ ਮੈਂ, ਹੱਲ ਵਾਹੁਣ ਵਾਲੇ

ਪ੍ਰੋ.ਮੋਹਨ ਸਿੰਘ :

ਮਾਂ, ਕੋਈ ਆਇਆ ਸਾਡੇ ਵਿਹੜੇ, ਪਿਆਰ ਪੰਧ

ਅੰਮ੍ਰਿਤਾ ਪ੍ਰੀਤਮ:

ਆਖਾਂ ਵਾਰਿਸ ਸ਼ਾਹ ਨੂੰ, ਅੰਨਦਾਤਾ *(Lecture 11)*

UNIT-II ਕਹਾਣੀ ਭਾਗ:

ਸੰਤ ਸਿੰਘ ਸੇਖੋਂ :

ਪੇਮੀ ਦੇ ਨਿਆਣੇ

ਸੁਜਾਨ ਸਿੰਘ :

ਕੁਲਫੀ

ਕੁਲਵੰਤ ਸਿੰਘ ਵਿਰਕ :

ਤੂੜੀ ਦੀ ਪੰਡ

ਗੁਰਦਿਆਲ ਸਿੰਘ :

ਸਾਂਝ *(Lecture 12)*

PART-B

UNIT-III

ਭਾਸ਼ਾ ਦਾ ਟਕਸਾਲੀ ਰੂਪ, ਭਾਸ਼ਾ ਤੇ ਉਪ-ਭਾਸ਼ਾ ਵਿਚ ਅੰਤਰ, ਪੰਜਾਬੀ ਦੀਆਂ ਉਪ-ਭਾਸ਼ਾਵਾਂ,ਪੰਜਾਬੀ ਭਾਸ਼ਾ:ਨਿਕਾਸ ਤੇ ਵਿਕਾਸ।

ਭਾਸ਼ਾ ਤੇ ਲਿਪੀ, ਗੁਰਮੁਖੀ ਲਿਪੀ ਦੀਆਂ ਵਿਸ਼ੇਸ਼ਤਾਵਾਂ, ਗੁਰਮੁਖੀ ਲਿਪੀ: ਨਿਕਾਸ ਤੇ ਵਿਕਾਸ।

(Lecture 11)

UNIT-IV

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BHCP-I-102-21	**CHEMISTRY LAB-I**	**L-0, T-0, P-4**	**2 Credits**

Pre-requisite: Understanding of senior secondary level Chemistry

Course Objectives: The objective of this course is to provide practical knowledge and illustrative experiments about various types of inorganic titrations and preparation of simple inorganic compounds.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand to calibrate and run the instruments for analysis.
CO2	Learn to the quantitative analysis of various metal ions/cations and anions.
CO3	Understand the various principles of different techniques involved in the quantitative analysis.
CO4	Learn to prepare various inorganic compounds

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

List of Experiments:

(A) Titrimetric Analysis

(i) Calibration and use of apparatus

(ii) Preparation of solutions of different Molarity/Normality of titrants

(B) Acid-Base Titrations

(i) Estimation of carbonate and hydroxide present together in mixture.

(ii) Estimation of carbonate and bicarbonate present together in a mixture.

(iii) Estimation of free alkali present in different soaps/detergents

(C) Oxidation-Reduction Titrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO4$ solution.

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(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.

(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Reference text:

1. Vogel, A.I. *A Textbook of Quantitative Inorganic Analysis*, ELBS.

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BHHL-105-21	Communicative English -I	L-2, T-0, P-0	2 Credits

Pre-requisite: Basic proficiency in Communication Skills

Course Objectives: The main objective of this course is:

- To help the students become proficient in LSRW-Listening, Speaking, Reading & Writing skills
- To help the students become the independent users of English language
- To develop in them vital communication skills, integral to their personal, social and professional interactions
- To teach them the appropriate language of professional communication
- To prepare them for job market

Course Outcomes: At the end of the course, the student will

CO1	acquire basic proficiency in reading &listening, writing and speaking skills
CO2	be able to understand spoken and written English language, particularly the language of their chosen technical field.
CO3	be able to converse fluently.
CO4	be able to produce on their own clear and coherent texts.
CO1	become proficient in professional communication, such as, interviews, group discussions, office environments, important reading skills as well as writing skills and thereby will have better job prospects.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	-	1	1	2	2	3	2	3	2	2
CO2	1	-	-	1	1	2	2	3	2	3	2	2
CO3	1	-	-	1	1	2	2	3	2	3	2	2
CO4	1	-	-	1	1	2	2	3	2	3	2	2
CO5	2	-	-	1	1	2	2	3	2	3	2	2

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Detailed Syllabus:

Part –A

UNIT I-(Literature)

(A) ***The Poetic Palette* (Orient Black Swan, Second Edition, 2016)**

The following poems from this anthology are prescribed:

1. Pippa's Song: Robert Browning
2. Apparently With No Surprise: Emily Dickinson
3. Fool and Flea: Jeet Thayil

(B) ***Prose Parables* (Orient Black Swan, 2013)**

The following stories from the above volume are prescribed:

a. The Kabuliwallah : Rabindranath Tagore
b. The Eyes Are Not Here: Ruskin Bond
c. Grief: Anton Chekov

UNIT-II

Vocabulary: Word Formation Processes; Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives; Synonyms, antonyms

Grammar: Subject-verb agreement; Noun-pronoun agreement; Misplaced modifiers; Articles Determiners; Modals; Prepositions;

PART-B

UNIT-III

Reading and Understanding: Close Reading; Comprehension;

UNIT-IV

Mechanics of Writing & Speaking Skills

Essay Writing (Descriptive/Narrative/Argumentative); Business letters; Précis Writing; Self Introductions; Group Discussion

TEXT AND REFERENCE BOOK

1. John Eastwood, Oxford Practice Grammar, Oxford University Press, 2014
2. Michael Swan, Practical English Usage, OUP. 1995.
3. F.T. Wood, Remedial English Grammar, Macmillan. 2007.
4. William Zinsser, On Writing Well, Harper Resource Book 2001.
5. Sanjay Kumar and Pushp Lata, Oxford University Press. 2011.
6. Communication Skills, Oxford University Press. 2011.
7. Liz Hamp-Lyons and Ben Heasly, Study Writing, Cambridge University Press. 2006.

BHHL-106A-21	**ਪੰਜਾਬੀ ਲਾਜ਼ਮੀ (Punjabi Compulsory)-I**	**L-2, T-0, P-0**	**2 Credits**

Pre-requisite: Understanding of senior secondary level Punjabi

Course Objectives: The objective of the course is:
1.To enhance the language ability of students.
2.To enhance the ability of Learning science and developing science literacy through local language teaching with science subjects.

Course Outcomes: At the end of the course, the student will be able to

CO1	Translate and transfer/broadcast the western scientific knowledge in the local language.
CO2	Translate and transfer the indigenous/traditional scientific knowledge available in local knowledge into English and other global languages.
CO3	Understand the society through Punjabi language, literature and culture
CO4	Learning science and in developing science literacy.
CO5	Improve the internal communication.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

ਸੰਖੇਪ ਰਚਨਾ (ਪ੍ਰੈਸੀ)
ਪੈਰ੍ਹਾ ਰਚਨਾ
ਸਰਲ ਅੰਗਰੇਜ਼ੀ ਪੈਰ੍ਹੇ ਦਾ ਪੰਜਾਬੀ ਅਨੁਵਾਦ

(Lecture 11)

TEXT AND REFERENCE BOOK:

1. ਸੰਪ.ਡਾ.ਮਹਿਲ ਸਿੰਘ, ਸਾਹਿਤ ਦੇ ਰੰਗ, ਰਵੀ ਸਾਹਿਤ ਪ੍ਰਕਾਸ਼ਨ, ਅੰਮ੍ਰਿਤਸਰ, 2016.

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BHHL-106B-21	ਮੁਢਲੀ ਪੰਜਾਬੀ (Mudhli Punjabi)-I	L-2, T-0, P-0	2 Credits

Pre-requisite: Understanding of senior secondary level Physics and Mathematics

Course Objectives: The objective of the course is to:
1. enhance the language ability of students.
2. enhance the ability of Learning science and developing science literacy through local language teaching with science subjects.

Course Outcomes: At the end of the course, the student will be able to

CO1	Translate and transfer/broadcast the western scientific knowledge in the local language.
CO2	Translate and transfer the indigenous/traditional scientific knowledge available in local knowledge into English and other global languages.
CO3	Understand the society through Punjabi language, literature and culture.
CO4	Learning science and in developing science literacy.
CO5	Improve the internal communication.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

Detailed Syllabus:

PART-A

UNIT I
ਪੈਂਤੀ ਅੱਖਰੀ (ਵਰਣਮਾਲਾ), ਅੱਖਰ ਕ੍ਰਮ
ਮਾਤਰਾਵਾਂ : ਮੁਢਲੀ ਜਾਣ-ਪਛਾਣ
ਲਗਾਖਰ :ਬਿੰਦੀ, ਟਿੱਪੀ, ਅੱਧਕ

UNIT-II
ਪੰਜਾਬੀ ਸ਼ਬਦ ਬਣਤਰ: ਮੁਢਲੀ ਜਾਣ-ਪਛਾਣ

ਮੂਲ ਸ਼ਬਦ , ਅਗੇਤਰ, ਪਿਛੇਤਰ

ਸਮਾਨਾਰਥਕ ਸ਼ਬਦ, ਵਿਰੋਧਾਰਥਕ ਸ਼ਬਦ

ਸ਼ੁੱਧ- ਅਸ਼ੁੱਧ: ਦਿੱਤੇ ਪੈਰ੍ਹੇ ਵਿੱਚੋਂ ਅਸ਼ੁੱਧ ਸ਼ਬਦ ਨੂੰ ਸ਼ੁੱਧ ਕਰਨਾ (11 Lectures)

PART-B

UNIT-III

ਹਫਤੇ ਦੇ ਸੱਤ ਦਿਨਾਂ ਦੇ ਨਾਂ
ਬਾਰ੍ਹਾਂ ਮਹੀਨਿਆਂ ਦੇ ਨਾਂ
ਰੁੱਤਾਂ ਦੇ ਨਾਂ
ਇਕ ਸੌ ਤੱਕ ਗਿਣਤੀ ਸ਼ਬਦਾਂ ਵਿਚ

UNIT-IV

ਸਧਾਰਣ ਸ਼ਬਦਾਂ ਦਾ ਅੰਗਰੇਜ਼ੀ ਤੋਂ ਪੰਜਾਬੀ ਅਨੁਵਾਦ

ਸਧਾਰਣ ਸ਼ਬਦਾਂ ਦਾ ਪੰਜਾਬੀ ਤੋਂ ਅੰਗਰੇਜ਼ੀ ਅਨੁਵਾਦ

TEXT AND REFERENCE BOOK

1.ਸੰਪ.ਡਾ.ਮਹਿਲ ਸਿੰਘ, ਸਾਹਿਤ ਦੇ ਰੰਗ, ਰਵੀ ਸਾਹਿਤ ਪ੍ਰਕਾਸ਼ਨ, ਅੰਮ੍ਰਿਤਸਰ, 2016.

SEMESTER -II

BSPH-121-21	Waves and Vibrations	L-4, T-0, P-0	4 Credits

Pre-requisite: Understanding of senior secondary level physics and Mathematics

Course Objectives: The objective of the course provides an exposure about simple harmonic motions, damped harmonic motions and forced oscillations. Students learns about the different waves, propagation of waves in various mediums and reflection/transmission of waves at the interface of mediums.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the simple and damped harmonic motion of an oscillator.
CO2	Understand Forced Vibrations and phenomenon of Resonance
CO3	Apply the Coupled oscillator to the real life problems.
CO4	Understand the transmission of signals and Electromagnetic Waves
CO5	Apply the knowledge obtained in this course to day-to-day problems.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	1	-	1	2	-	2	3	2	3
CO2	2	2	1	2	1	1	1	-	1	3	2	3
CO3	3	2	-	2	1	1	2	-	1	3	2	3
CO4	2	2	-	2	1	1	2	1	1	3	3	1
CO5	2	2	-	2	1	1	2	1	1	3	3	3

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Detailed Syllabus:

PART-A

UNIT-I

Simple and Damped Harmonic Motion: Simple harmonic motion, energy of a SHO, Compound pendulum, Torsional pendulum, Electrical Oscillations, Lattice Vibrations, Transverse Vibrations of a mass on a string, Anharmonic Oscillations. Damped simple harmonic motion, Decay of free Vibrations due to damping, types of damping, Determination of damping coefficients: Logarithmic decrement, relaxation time and Q-factor. Electromagnetic damping.

(12 Lectures)

UNIT-II

Forced Vibrations and Resonance: Forced mechanical and electrical oscillator. Transient and Steady State Oscillations, Displacement and velocity variation with driving force frequency, Variation of phase with frequency resonance, Power supplied to forced oscillator by the driving force. Q-factor and band width of a forced oscillator, Electrical and nuclear magnetic resonances.

(12 lectures)

PART-B

UNIT-III

Coupled Oscillations: Stiffness coupled oscillators, Normal coordinates and modes of vibrations. Inductance coupling of electrical oscillators, Normal frequencies, Forced vibrations and resonance for coupled oscillators, Masses on string-coupled oscillators.

Waves in Physical Media: Types of waves, wave equation (transverse) and its solution characteristics impedance of a string, Impedance matching, Reflection and Transmission of waves at boundary, Energy of vibrating string, wave and group velocity. (12 Lectures)

UNIT-IV

Transmission of signals and Electromagnetic Waves: Transmission of a non-monochromatic wave, Frequency range and Signal duration, Bandwidth theorem, Group and phase velocities, Electromagnetic theory of dispersion, Doppler effect. Electromagnetic (EM) Waves: Maxwell Equations, Wave equation, EM waves in a medium of finite ε, μ and σ. Energy flow due to a plane EM wave; EM waves in a conducting medium, Skin depth. (12 Lectures)

Text and Reference Books:

1. Text Book of Vibrations and Waves: S.P. Puri (Macmillan India), 2004.
2. The Physics of Vibrations and Waves: H.J. Pain (Wiley and ELBS), 2013.
3. N.K. Bajaj, The Physics of Waves and Oscillations, Tata McGraw Hill, 1998.

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BSHP-122-21	**Electricity and Magnetism**	**L-4, T-0, P-0**	**4 Credits**

Pre-requisite: Basic knowledge of Electricity and Magnetism at high school level.

Course Objectives: The objective of the course is to expose the students to the formal structure of electricity and magnetism so that they can use these as per their requirement.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand and describe the different concepts of electrostatics and magnetostatics
CO2	Apply the knowledge of Maxwell's equation and flow of electromagnetic waves in real problems.
CO3	Analyze the wave propagation in different media
CO4	Compare the different types of polarization
CO5	have a solid foundation in electromagnetism fundamentals required to solve problems

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	2	1	2	1	2	3	2	2
CO2	3	2	1	-	2	2	1	1	1	3	1	1
CO3	3	2	3	-	2	1	2	1	1	3	1	1
CO4	3	2	3	2	-	2	2	1	1	3	1	1
CO5	2	2	3	2	-	2	2	1	1	3	1	1

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Detailed Syllabus:

PART-A

UNIT I

Review of Vector Analysis and Electrostatics: scalar and vector product; gradient, divergence and curl and their significance; Gauss-divergence theorem and Stoke's theorem (statement only); Electrostatic field; electric flux; Gauss's law of electrostatics; Applications of Gauss law-Electric filed due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charge sheet; Electric potential as line integral of electric field, potential due to point charge and electric dipole; calculation of electric field from potential; Poisson's equation and Laplace's equation(Cartesian coordinate); Capacitance; capacitance of a spherical conductor and cylindrical capacitor, Energy per unit volume in electrostatic field, Dielectric medium, dielectric polarization and its types, Displacement vector, Boundary conditions *(11 Lectures)*

UNIT-II

Magnetostatics: Magnetic flux; magnetic flux density; Faraday's law; magnetomotive force; Biot-Savart's law and its applications-straight conductor, circular coil, divergence and curl of magnetic field; Ampere's work law in differential form; Magnetic vector potential; ampere's force law; magnetic vector potential; Energy stored in a magnetic field, boundary conditions on magnetic fields. *(10 Lectures)*

PART-B

UNIT-III

Maxwell's Equations and Poynting Vector: Equation of continuity for time varying fields; Inconsistency of ampere's law; concept of sinusoidal time variations (Phasor notation); Maxwell's equations with physical significance; Maxwell equations in free space, static field and in Phasor notation; Difference between displacement current and conduction current; Concept of Poynting vector; Poynting Theorem. *(11 Lectures)*

UNIT-IV

Electromagnetic Waves: Wave equation in free space or non-conducting or lossless medium; wave equation for conducting medium; wave propagation in lossless and conducting medium (phasor form); Propagation characteristics of EM waves in free space, lossless and in conducting medium; Uniform plane waves and solution; relation between electric and magnetic fields of an electromagnetic wave; Linear, circular and elliptical polarization; depth of penetration, Reflection of waves by a perfect conductor: normal incidence and oblique incidence; Reflection and transmission of electromagnetic waves from a non-conducting medium-vacuum interface for normal incidence. *(12 Lectures)*

Reference Books:

1. David Griffiths, Introduction to Electrodynamics, Pearson Education India Learning Private Limited; 4 edition.
2. Edward C Jordan and Keith G Balmain, Electromagnetic waves and radiating systems, Prentice Hall
3. Kraus John D, Electromagnetics, McGraw-Hill Publisher
4. W. Saslow, Electricity, magnetism and light, Academic Press
5. A Textbook of Electricity and Magnetism, S K Sharma, Shalini Sharma, Publisher: S Dinesh & Co.

BSHP-123-21	Physics Lab-II	L-0, T-0, P-4	2 Credits

Pre-requisites (if any): High-school education with Physics lab as one of the subject.

Course Objectives: The aim and objective of the Physics Lab course is to introduce the students of B. Sc. (Hons.) Physics to the formal structure of wave and vibrations and mechanics so that they can use these as per their requirement.

Course Outcomes: At the end of the course, the student will be

CO1	Able to understand the theoretical concepts learned in the theory course.
CO2	Trained in carrying out precise measurements and handling equipment.
CO3	Learn to draw conclusions from data and develop skills in experimental design.
CO4	Able to understand the principles of error analysis and develop skills in experimental design.
CO5	Able to document a technical report which communicates scientific information in a clear and concise manner.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	2	1	2	3	2	3
CO2	3	3	1	-	2	2	1	1	1	3	2	3
CO3	3	3	2	-	2	1	2	1	1	3	2	3
CO4	3	2	2	2	-	2	2	1	1	3	2	3
CO5	2	2	2	2	-	2	2	1	1	3	2	3

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Note: Students are expected to perform about 8-10 experiments from the following list, selecting minimum of 6-7 from the Physical Lab and 2-3 from the Virtual lab.

List of experiments:

1. Measurements of length (or diameter) using vernier caliper and screw gauge.
2. Measurement of volume using travelling microscope. Use of Plumb line and Spirit level.
3. To determine the frequency of an electrically maintained tuning fork in a) Transverse mode of vibration b) Longitudinal mode of vibration.
4. To verify the law of vibrating string Using Melde's experiment.
5. To compare mass per unit length of two strings by Melde's experiment.
6. To find out the frequency of AC mains using electric-vibrator/sonometer.
7. To determine the horizontal and vertical distance between two points using a Sextant.
8. To determine the height of an inaccessible object using a Sextant.
9. To determine the angular diameter of the sun using the sextant.
10. To determine the angular acceleration α, torque τ, and Moment of Inertia of flywheel.
11. To study the Motion of a Spring and calculate (a) Spring Constant (b) Value of **g** and (c) Modulus of rigidity.
12. To determine the time period of a simple pendulum for different length and acceleration due to gravity.
13. To study the variation of time period with distance between centre of suspension and centre of gravity for a compound pendulum and to determine: (i) Radius of gyration of the bar about an axis through its C.G. and perpendicular to its length. (ii) The value of g in the laboratory.
14. To find the moment of inertia of an irregular body about an axis through its C.G with the torsional pendulum.

Reference book and suggested readings:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal.
4. Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.
6. Practical Physics, C L Arora. S. Chand & Company Ltd.
7. http://www.vlab.co.in

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BSHM-204-21	Vector Algebra & Vector Analysis	L-4, T-1, P-0	4 Credits

Pre-requisite: Elementary calculus of matric level.

Course Objectives: The objectives of this course are to make the students understand the following:

1. The fundamental concepts of Scalars and Vector algebra.
2. The geometrical meaning of projections and orthogonality.
3. Applications of gradient, divergence and curl.
4. Geometric meaning of scalar and vector valued functions, gradient of scalar point function.
5. The utility of Gauss, Green and Stokes Theorem.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the basic concepts of Scalars and Vector algebra.
CO2	Visualize all concepts geometrically.
CO3	Apply the knowledge of dot product and cross product in finding projections, area and orthogonality.
CO4	Utilize the concept of scalar and vector valued functions, gradient of scalar point function, divergence and curl of vector point functions, their geometrical interpretation.
CO5	Acquire the knowledge of the concept of relation between cartesian, cylindrical and spherical polar coordinates, Gauss, Green and Stokes theorem.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

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Detailed Syllabus:

PART-A

UNIT I

Definitions of Scalars, vectors, position vector, unit vector, types of vectors, Addition of vectors, direction ratios, direction cosines, multiplication by a scalar, dot product, cross product of vectors, projection of vectors on a line.

UNIT-II

Vector joining two points, section formula, angle between two vectors, Cauchy-Schwartz inequality, Solenoidal vectors, orthogonality, Area of triangle, area of parallelogram, Scalar and vector product of three vectors

PART-B

UNIT-III

Scalar valued point functions, vector valued point functions, Derivative along a curve, directional derivatives, Differentiation and partial differentiation of a vector function. Derivative of sum, dot product and cross product of two vectors, Gradient, divergence and curl Gradient of a scalar point function. Geometrical interpretation of gradient of a scalar point function (grad φ).

UNIT-IV

Divergence and curl of a vector point function, Character of divergence and curl of a vector point function, relation between Cartesian and cylindrical or spherical coordinates, Statements of Theorems of Gauss, Green and Stokes (without proof).

TEXT AND REFERENCE BOOK

1. Mathematics, A Text book for Class XII (Parts I & II), New Delhi: NCERT, 2003. (Unit I & II)
2. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
3. H. Anton, I. Bivens and S. Davis, Calculus, John Wiley and Sons (Asia) P. Ltd. 2002.
4. P.C. Matthew's, Vector Calculus, Springer Verlag London Limited, 1998.

BSHC-113-21	**ORGANIC CHEMISTRY**	**L-4, T-0, P-0**	**4 Credits**

Pre-requisite: Understanding of senior secondary level Physics and Mathematics

Course Objectives:

1. To teach the basic principles, reaction mechanisms and stereochemistry of organic compounds.
2. To impart knowledge regarding physical properties and chemical reactions of alkanes, alkenes, dienes, alkynes, arenes, alkyl and aryl halides etc.
3. To predict and account for the most commonly encountered reaction mechanisms (substitution, addition, and elimination) in organic chemistry.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the fundamental concepts of organic chemistry i.e. structure, bonding and various effects in organic compounds.
CO2	To learn the stereochemistry viz. optical isomerism, stereoisomerism and conformational isomerism of organic compounds.
CO3	To study the various known reactive intermediate in organic synthesis.
CO4	To learn the fundamental and advanced concepts of reaction mechanisms along with the study of reaction mechanisms in various types of substitution addition and elimination reactions.
CO5	To predict the relationships between organic chemical structures and their reactivity.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

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Detailed Syllabus:

PART-A

Unit-I

Basics of Organic Chemistry

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. *Electronic Displacements:* Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleo phlicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

Unit-II

Stereochemistry:

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemicmixture and resolution. Relative and absolute configuration: D/L and R/S designations.

A. Carbon-Carbon sigma bonds formation:-

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

PART-B

Unit-III

Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ AntiMarkownikoff addition), mechanism of oxymercuration-demercuration, hydroboration oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation(oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene. *Reactions of alkynes:* Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

Unit-IV

Cycloalkanes and Conformational Analysis

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

Aromatic Hydrocarbons

Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

Text and Reference Books:

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.
5. Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.

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BSHC-119-21	**CHEMISTRY LAB-II**	**L-0, T-0, P-2**	**2 Credits**

Pre-requisite: Understanding of senior secondary level Chemistry

Course Objectives: which will act as a strong background if he/she chooses to pursue physics as a career.

Course Outcomes: At the end of the course, the student will be able to

CO1	
CO2	
CO3	
CO4	
CO5	

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

List of Experiments:

1. Checking the calibration of the thermometer
2. Purification of organic compounds by crystallization using the following solvents: a) Water b) Alcohol, and c) Alcohol-Water.
3. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100°C by distillation and capillary method)
6. Chromatography a) Separation of a mixture of two amino acids by ascending and horizontal paper chromatography b) Separation of a mixture of two sugars by ascending paper chromatography, c) Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

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Reference Books

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009).
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012).

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BHHL-115-21	Communicative English-II	L-2, T-0, P-0	2 Credits

Pre-requisite: Basic proficiency in communicative English

Course Objectives: This course is designed to

- help the students become proficient in LSRW-Listening, Speaking, Reading & Writing skills
- help the students become the independent users of English language
- develop in them vital communication skills, integral to their personal, social and professional interactions
- teach them the appropriate language of professional communication
- prepare them for job market

Course Outcomes: At the end of the course, the student will be able to

CO1	Students will acquire basic proficiency in reading &listening, writing and speaking skills.
CO2	Students will be able to understand spoken and written English language, particularly the language of their chosen technical field.
CO3	They will be able to converse fluently.
CO4	They will be able to produce on their own clear and coherent texts.
CO5	Students will become proficient in professional communication such as interviews, group discussions, office environments, important reading skills as well as writing skills and thereby will have better job prospects.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	-	1	1	2	2	3	2	3	2	2
CO2	1	-	-	1	1	2	2	3	2	3	2	2
CO3	1	-	-	1	1	2	2	3	2	3	2	2
CO4	1	-	-	1	1	2	2	3	2	3	2	2
CO5	2	-	-	1	1	2	2	3	2	3	2	2

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Detailed Syllabus:

Part –A

UNIT I-(Literature)

(A) ***The Poetic Palette*** **(Orient Black Swan, Second Edition, 2016)**

The following poems from this anthology are prescribed:

1. The Soul's Prayer: Sarojini Naidu
2. I Sit and Look Out: Walt Whitman
3. Women's Rights: Annie Louise Walker

(B) ***Prose Parables*** **(Orient Black Swan, 2013)**

The following stories from the above volume are prescribed:

1. The Doctor's Word: R.K. Narayan
2. The Doll's House: Katherine Mansfield
3. Dusk: H.H. Munroe (Saki)

UNIT-II

Vocabulary: Standard abbreviations; One word substitution; Word Pairs (Homophones/ Homonyms)

Grammar: Sentence Structures; Use of phrases and clauses in sentences; Transformation of Sentences; Importance of proper punctuation

PART-B

UNIT-III

Reading and Understanding: Summary Paraphrasing; Analysis and Interpretation; Translation (from Hindi/Punjabi to English and vice-versa)

UNIT-IV

Mechanics of Writing & Speaking Skills: Report writing; Career Documents- Job applications, Resume/CV writing, Common Everyday Situations: Conversations & Dialogues, Formal Presentations

TEXT AND REFERENCE BOOK

1. John Eastwood, Oxford Practice Grammar, Oxford University Press, 2014
2. Michael Swan, Practical English Usage, OUP. 1995.
3. F.T. Wood, Remedial English Grammar, Macmillan. 2007.
4. William Zinsser, On Writing Well, Harper Resource Book 2001.
5. Sanjay Kumar and Pushp Lata, Oxford University Press. 2011.
6. Communication Skills, Oxford University Press. 2011.
7. Liz Hamp-Lyons and Ben Heasly, Study Writing, Cambridge University Press. 2006.

BHHL-116A-21	ਪੰਜਾਬੀ ਲਾਜ਼ਮੀ (Punjabi Compulsory)-II	L-2, T-0, P-0	2 Credits

Pre-requisite: Understanding of senior secondary level Punjabi

Course Objectives: The objective of the course is to enhance the ability of via Learning science and developing science literacy through local language teaching with science subjects.

Course Outcomes: At the end of the course, the student will be able to

CO1	Translate and transfer/broadcast the western scientific knowledge in the local language.
CO2	Translate and transfer the indigenous/traditional scientific knowledge available in local knowledge into English and other global languages.
CO3	Understand the society through Punjabi language, literature and culture
CO4	Learning science and in developing science literacy.
CO5	Improve the internal communication.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

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Detailed Syllabus:

PART-A

UNIT I :

ਡਾ.ਹਰਿਭਜਨ ਸਿੰਘ:

ਅਪ੍ਰਮਾਇਕ, ਤੇਰੇ ਹਜ਼ੂਰ ਮੇਰੀ ਹਾਜ਼ਰੀ ਦੀ ਦਾਸਤਾਨ

ਸ਼ਿਵ ਕੁਮਾਰ ਬਟਾਲਵੀ:

ਕੰਡਿਆਲੀ ਥੋਰ੍ਹ, ਧਰਮੀ ਬਾਬਲ ਪਾਪ ਕਮਾਇਆ, ਰੁੱਖ

ਪਾਸ਼:

ਇਨਕਾਰ,ਸਭ ਤੋਂ ਖਤਰਨਾਕ,ਦਹਿਕਦੇ ਅੰਗਿਆਰਾਂ 'ਤੇ

ਸੁਰਜੀਤ ਪਾਤਰ:

ਹੁਣ ਘਰਾਂ ਨੂੰ ਪਰਤਣਾ, ਕੁਝ ਕਿਹਾ ਤਾਂ..., ਪੁਲ *(Lecture 12)*

UNIT-II

ਕਹਾਣੀ ਭਾਗ:

ਸੰਤੋਖ ਸਿੰਘ ਧੀਰ:

ਕੋਈ ਇਕ ਸਵਾਰ

ਪ੍ਰੇਮ ਪ੍ਰਕਾਸ਼:

ਲੱਛਮੀ

ਮੋਹਨ ਭੰਡਾਰੀ :

ਘੋਟਣਾ

ਵਰਿਆਮ ਸਿੰਘ ਸੰਧੂ :

ਆਪਣਾ ਆਪਣਾ ਹਿੱਸਾ *(Lecture 11)*

PART-B

UNIT-III

ਪੰਜਾਬੀ ਭਾਸ਼ਾ ਦੀਆਂ ਵਿਸ਼ੇਸ਼ਤਾਵਾਂ

ਪੰਜਾਬੀ ਭਾਸ਼ਾ ਉਪਰ ਪਏ ਪ੍ਰਭਾਵ *(Lecture 12)*

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UNIT-IV

ਰਿਪੋਰਟਿੰਗ, ਸਮਾਚਾਰ ਲਿਖਣ ਦੀ ਵਿਧੀ ਤੇ ਤੱਤ

ਪੰਜਾਬੀ ਪੈਰ੍ਹੇ ਦਾ ਸਰਲ ਅੰਗਰੇਜ਼ੀ ਅਨੁਵਾਦ
ਦਫਤਰੀ ਚਿੱਠੀ ਪੱਤਰ

TEXT AND REFERENCE BOOK:

1. ਸੰਪ.ਡਾ.ਮਹਿਲ ਸਿੰਘ, ਸਾਹਿਤ ਦੇ ਰੰਗ, ਰਵੀ ਸਾਹਿਤ ਪ੍ਰਕਾਸ਼ਨ, ਅੰਮ੍ਰਿਤਸਰ, 2016.

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BHHL-116B-21	**ਮੁਢਲੀ ਪੰਜਾਬੀ (Mudhli Punjabi)-II**	**L-2, T-0, P-0**	**2 Credits**

Pre-requisite: Understanding of senior secondary level Physics and Mathematics

Course Objectives: The objective of the course is:
1.To enhance the language ability of students.
2.To enhance the ability of Learning science and developing science literacy through local language teaching with science subjects.

Course Outcomes: At the end of the course, the student will be able to

CO1	Translate and transfer/broadcast the western scientific knowledge in the local language.
CO2	Translate and transfer the indigenous/traditional scientific knowledge available in local knowledge into English and other global languages.
CO3	Understand the society through Punjabi language, literature and culture.
CO4	Learning science and in developing science literacy.
CO5	Improve the internal communication.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

Detailed Syllabus:

PART-A

UNIT I

ਸ਼ਬਦ ਸ਼੍ਰੇਣੀਆਂ : ਪਛਾਣ ਤੇ ਵਰਤੋਂ-

ਨਾਂਵ

ਪੜਨਾਂਵ

ਵਿਸ਼ੇਸ਼ਣ

ਕਿਰਿਆ

ਕਿਰਿਆ ਵਿਸ਼ੇਸ਼ਣ (12 Lectures)

UNIT-II

ਰੋਜ਼ਾਨਾ ਵਰਤੋਂ ਦੀ ਪੰਜਾਬੀ ਸ਼ਬਦਾਵਲੀ:

ਬਾਜ਼ਾਰ, ਵਪਾਰ, ਰਿਸ਼ਤੇ-ਨਾਤੇ ਤੇ ਕਿੱਤਿਆਂ ਸਬੰਧੀ। (12 Lectures)

PART-B

UNIT-III

ਪੰਜਾਬੀ ਵਾਕ ਬਣਤਰ :

ਸਧਾਰਣ ਵਾਕ

ਸੰਯੁਕਤ ਵਾਕ

ਮਿਸ਼ਰਤ ਵਾਕ

(12 Lectures)

UNIT-IV

ਸਧਾਰਣ ਵਾਕਾਂ ਦਾ ਅੰਗਰੇਜ਼ੀ ਤੋਂ ਪੰਜਾਬੀ ਅਨੁਵਾਦ

ਸਧਾਰਣ ਵਾਕਾਂ ਦਾ ਪੰਜਾਬੀ ਤੋਂ ਅੰਗਰੇਜ਼ੀ ਅਨੁਵਾਦ (11 Lectures)

TEXT AND REFERENCE BOOK:

1. ਸੰਪ.ਡਾ.ਮਹਿਲ ਸਿੰਘ, ਸਾਹਿਤ ਦੇ ਰੰਗ, ਰਵੀ ਸਾਹਿਤ ਪ੍ਰਕਾਸ਼ਨ, ਅੰਮ੍ਰਿਤਸਰ, 2016.

Reference books and suggested reading:

1. "Fundamentals of Physics", 6th Ed., D. Halliday, R. Resnick and J. Walker, John Wiley and Sons, Inc., New York, 2001.
2. "Physics", M. Alonso and E.J. Finn, Addison Wesley, 1992.
3. "Fundamentals of Optics", 4th Ed., F.A. Jenkins and H.E. White, McGraw-Hill Book Co., 1981.
4. "Optics", A Ghatak, Tata-McGraw Hill, New Delhi, 1992
5. "Vibration and Waves", A.P. French, Arnold-Heinemann, New Delhi, 1972.
6. "Students Reference Manual for Electronic Instrumentation Laboratories",
7. "Laboratory Experiments in College Physics", C.H. Bernard and C.D. Epp, John Wiley and Sons, Inc., New York, 1995.
8. "Practical Physics", G.L. Squires, Cambridge University Press, Cambridge, 1985.
9. "Experiments in Modern Physics", A.C. Melissinos, Academic Press, N.Y., 1966.
10. "Practical Physics", C L Arora. S. Chand & Company LTD.
11. http://www.vlab.co.in

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Annexure-III

M.Sc. Physics

Course Structure and Syllabus

(Based on Choice Based Credit System)

2021 onwards

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Examination and Evaluation

Theory			
S. No.	**Evaluation criteria**	**Weightage in Marks**	**Remarks**
1	Mid term/sessional Tests	24	Internal evaluation (40 Marks)
2	Attendance	6	MSTs, Quizzes, assignments, attendance, etc., constitute internal evaluation. Average of two mid semester test will be considered for evaluation.
3	Assignments	10	
4	End semester examination	60	External evaluation (60 Marks)
5	Total	100	Marks may be rounded off to nearest integer.
Practical			
1	Evaluation of practical record/ Viva Voice	30	Internal evaluation (50 Marks)
2	Attendance	5	
3	Seminar/Presentation	15	
4	Final Practical Performance + Viva Voice	25	External evaluation (25 Marks)
5	Total	75	Marks may be rounded off to nearest integer.

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M.Sc. (Physics) Program

Duration: 2 Years (Semester System)

This M.Sc. (Physics) Program includes various core, electives, and other interdisciplinary courses. The diverse lab experiments allow students to understand the fundamental aspects of the subject. A choice of advanced elective courses offers a glimpse in the frontier areas of research and allow students to work on research project as an integral part of their M.Sc. program. The program also provides adequate exposure to the students for pursuing higher education in the field of technology, research and development in Physics and related areas (M.Phil./Ph.D.) and other job opportunities in academia and industry.

Eligibility:

Pass B.Sc. with 50% marks having Physics as one of the subject. A relaxation of 5% is given in case of candidates belonging to SC/ST category.

PROGRAM EDUCATIONAL OBJECTIVES: At the end of the program, the student will be able to:

PEO1	Apply principles of basic scientific concepts in understanding, analysis, and prediction of physical systems.
PEO2	Develop human resource with specialization in theoretical and experimental techniques required for career in academia, research and industry.
PEO3	Engage in lifelong learning and adapt to changing professional and societal needs.

PROGRAM OUTCOMES: At the end of the program, the student will be able to:

PO1	Apply the scientific knowledge to solve the complex physics problems.
PO2	Identify, formulate, and analyze advanced scientific problems reaching substantiated conclusions using first principles of mathematics, physical, and natural sciences.
PO3	Design solutions for advanced scientific problems and design system components or processes that meet the specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal consideration.
PO4	Use research-based knowledge and methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	Create, select, and apply appropriate techniques, resources, and modern scientific tools to complex physics problems with an understanding of the limitations.
PO6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues, and the consequent responsibilities relevant to the professional scientific practice.
PO7	Understand the impact of the scientific solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	Apply ethical principles and commit to the norms of scientific practice.
PO9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	Communicate effectively on scientific activities with the Scientific/Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	Demonstrate knowledge and understanding of the scientific principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	Recognize the need for,and have the preparation and ability to engage in independent and life-long learning in the broadest context of scientific and technological change.

PROGRAM SPECIFIC OUTCOMES: At the end of the program, the student will be able to:

PSO1	Understand the basic and advance concepts of different branches of physics.
PSO2	Perform and design experiments in the areas of electronics, atomic, nuclear, condensed matter, and computational physics.
PSO3	Apply the concepts of physics in specialized areas of condensed, nuclear, renewable energies, particle physics, etc., in industry, academia, research and day today life.

SEMESTER FIRST

Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Credits
		L	T	P	Internal	External		
MSPH-411-21	Mathematical Physics-I	3	1	-	40	60	100	4
MSPH-412-21	Classical Mechanics	3	1	-	40	60	100	4
MSPH-413-21	Quantum Mechanics-I	3	1	-	40	60	100	4
MSPH-414-21	Electronics	3	1	-	40	60	100	4
MSPH-415-21	Computational Physics	3	1	-	40	60	100	4
MSPH-416-21	Electronics Lab	-	-	6	50	25	75	3
MSPH-417-21	Computational Physics Lab-I	-	-	6	50	25	75	3
TOTAL		15	5	12	300	350	650	26

SEMESTER SECOND

Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Credits
		L	T	P	Internal	External		
MSPH-421-21	Mathematical Physics-II	3	1	-	40	60	100	4
MSPH-422-21	Statistical Mechanics	3	1	-	40	60	100	4
MSPH-423-21	Quantum Mechanics-II	3	1	-	40	60	100	4
MSPH-424-21	Classical Electrodynamics	3	1	-	40	60	100	4
MSPH-425-21	Atomic and Molecular Physics	3	1	-	40	60	100	4
MSPH-426-21	Atomic, Nuclear, and Particle Physics Lab	-	-	6	50	25	75	3
MSPH-427-21	Computational Physics Lab-II	-	-	6	50	25	75	3
	TOTAL	15	5	12	300	350	650	26

L: Lectures T: Tutorial P: Practical

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SEMESTER THIRD

Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Credits
		L	T	P	Internal	External		
MSPH-531-21	Condensed Matter Physics	3	1	-	40	60	100	4
MSPH-532-21	Nuclear Physics	3	1	-	40	60	100	4
MSPH-533-21	Particle Physics	3	1	-	40	60	100	4
MSPH-534-21 MSPH-535-21 MSPH-536-21	Elective Subject-I	3	1	-	40	60	100	4
MSPH-537-21 MSPH-538-21 MSPH-539-21	Elective Subject-II	3	1	-	40	60	100	4
MSPH-540-21	Condensed Matter Physics Lab	-	-	6	50	25	75	3
TOTAL		15	5	6	250	325	575	23

SEMESTER FOURTH

Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Credits
		L	T	P	Internal	External		
MSPH-541-21 MSPH-542-21 MSPH-543-21	Elective Subject-III	3	1	-	40	60	100	4
MSPH-544-21 MSPH-545-21 MSPH-546-21	Elective Subject-IV	3	1	-	40	60	100	4
MSPH-547-21	Dissertation	12			200	100	300*	12
TOTAL		6	14		280	220	500	20

***Evaluation criteria as per IKGPTU norms.**

TOTAL NUMBER OF CREDITS = 95

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LIST OF DEPARTMENTAL/INTERDISCIPLINARY ELECTIVES

Elective Subject-I

S. No.	Name of the Subject	Code
1	Fibre optics and non-linear optics	MSPH-534-21
2	Radiation Physics	MSPH-535-21
3	Nonlinear Dynamics	MSPH-536-21

Elective Subject -II

S. No.	Name of the Subject	Code
1	Plasma Physics	MSPH-537-21
2	Structures, Spectra and Properties of Biomolecules	MSPH-538-21
3	Science of Renewable Source of Energy	MSPH-539-21

Elective-III

S. No.	Name of the Subject	Code
1	Physics of Nanomaterials	MSPH-541-21
2	Experimental Techniques in Nuclear and Particle Physics	MSPH-542-21
3	Superconductivity and Low Temperature Physics	MSPH-543-21

Elective-IV

	Name of the Subject	Code
1	Advanced Condensed Matter Physics	MSPH-544-21
2	Advanced Particle Physics	MSPH-545-21
3	Environment Physics	MSPH-546-21

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Guidelines for the evaluation of Dissertation:

<table>
<tr><th colspan="7">Internal Assessment</th></tr>
<tr><td rowspan="2">Departmental Presentation</td><td colspan="2">Communication and presentation</td><td colspan="2">Response to queries</td><td>Maximum Marks</td><td>Evaluated by</td></tr>
<tr><td colspan="2">20</td><td colspan="2">30</td><td>50</td><td>Committee Member:
1.Head
2.Supervisor
3.One of Faculty Member</td></tr>
<tr><td rowspan="2">Dissertation</td><td>Plagiarism</td><td>Subject Matter</td><td>Usage of Language</td><td>Publication/Presentation in Conference</td><td rowspan="2">150</td><td rowspan="2"></td></tr>
<tr><td>25</td><td>70</td><td>25</td><td>30</td></tr>
<tr><th colspan="7">External Assessment</th></tr>
<tr><td rowspan="2">External Examiner</td><td colspan="4">Subject Matter</td><td rowspan="2">50</td><td rowspan="2"></td></tr>
<tr><td colspan="4">50</td></tr>
<tr><td rowspan="2">Viva Voce</td><td colspan="2">Communication and Presentation</td><td colspan="2">Response to queries</td><td rowspan="2">50</td><td rowspan="2">Committee Member:
1.Head
2.External Expert
3.Supervisor
4. Director (MC) nominee</td></tr>
<tr><td colspan="2">20</td><td colspan="2">30</td></tr>
<tr><td colspan="5">Total</td><td>300</td><td></td></tr>
</table>

Evaluation Process:

1. The subject matter evaluation can further be defined on the basis of Title, Review of literature/Motivation, Objectives, Methodology, Results and discussions, and Conclusion.
2. The usage of language and the subject matter shall be evaluated by the supervisor. Out of 300 marks, 95 marks are to be evaluated by the concerned supervisor.
3. Total 15% Plagiarism is admissible for submission of the dissertation. For (0-5)% of plagiarism, candidate should be awarded 25 marks. For >5%-10% candidate should be awarded 15 marks and for the range of > 10% to < 15%, candidate should be awarded 5 marks.
4. For publication candidate should be awarded full 30 marks and for presenting the work related to dissertation, candidate should be awarded 25 marks.

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Detailed Syllabus:

1. **Complex Variables**: Introduction, Cauchy-Riemann conditions, Cauchy's Integral formula, Laurent expansion, singularities, calculus of residues, evaluation of definite integrals, Dispersion relation. *(Lectures 10)*

2. **Delta and Gamma Functions:** Dirac delta function, Delta sequences for one dimensional function, properties of delta function, Gamma function, factorial notation and applications, Beta function. *(Lectures 7)*

3. **Differential Equations:** Partial differential equations of theoretical physics, boundary value, problems, Neumann & Dirichlet Boundary conditions, separation of variables, singular points, series solutions, second solution. *(Lectures 8)*

4. **Special Functions:** Bessel functions of first and second kind, Generating function, integral representation and recurrence relations for Bessel's functions of first kind, orthogonality. Legendre functions: generating function, recurrence relations and special properties, orthogonality, various definitions of Legendre polynomials, Associated Legendre functions: recurrence relations, parity and orthogonality, Hermite functions, Laguerre functions. *(Lectures 10)*

5. **Elementary Statistics:** Introduction to probability theory, random variables, Binomial, Poisson and Normal distribution. *(Lectures 5)*

Text Books:

1. Mathematical Methods for Physicists: G. Arfken and H.J. Weber (Academic Press, SanDiego) 7th edition, 2011.

Reference Books:

1. Mathematical Physics: *P.K. Chattopadhyay (Wiley Eastern, New Delhi), 2004.*
2. Mathematical Physics: *A.K. Ghatak, I.C. Goyal and S.J. Chua (MacMillan, India, Delhi),1986.*
3. Mathematical Methods in the Physical Sciences – *M.L. Boas (Wiley, New York) 3rd edition, 2007.*
4. Special Functions: *E.D. Rainville (MacMillan, New York), 1960.*
5. Mathematical Methods for Physics and Engineering: *K.F. Riley, M.P. Hobson and S.J. Bence (Cambridge University Press, Cambridge) 3rd ed., 2006.*

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MSPH-412-21	CLASSICAL MECHANICS	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of graduate level physics

Course Objectives: The aim and objective of the course on **Classical Mechanics** is to train the students of M.Sc. students in the Lagrangian and Hamiltonian formalisms so that they can use these in the modern branches of physics such as Quantum Mechanics, Quantum Field Theory, Condensed Matter Physics, Astrophysics, etc.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the necessity of Action, Lagrangian, and Hamiltonian formalism.
CO2	Use d'Alambert principle and calculus of variations to derive the Lagrange equations of motion.
CO3	Describe the motion of a mechanical system using Lagrange-Hamilton formalism.
CO4	Apply essential features of a classical physics problem (like motion under central force, periodic motions, etc.) to set up and solve the appropriate physics problems.
CO5	Appreciate the theory of rigid body motion which is important in several areas of physics e.g., molecular spectra, acoustics, vibrations of atoms in solids, coupled mechanical oscillators, electrical circuits, etc..

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	1	1	2	2	2	2	2
CO2	3	2	2	2	2	1	1	2	2	2	2	2
CO3	3	2	2	2	2	1	1	2	2	2	2	2
CO4	3	2	2	2	1	1	1	2	2	2	2	2
CO5	3	2	2	2	1	1	1	2	2	2	2	2

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Detailed Syllabus:

1. **Lagrangian Formulation:** Mechanics of a system of particles; constraints of motion, generalized coordinates, d'Alembert Principle and Lagrange's velocity-dependent forces and the dissipation function, Applications of Lagrangian formulation. *(Lectures 7)*
2. **Hamilton's Principles:** Calculus of variations, Hamilton's principle, Lagrange's equation from Hamilton's principle, extension to nonholonomic systems, advantages of variational principle formulation, symmetry properties of space and time and conservation theorems. *(Lectures 7)*
3. **Hamilton's Equations:** Legendre Transformation, Hamilton's equations of motion, Cyclic coordinates, Hamilton's equations from variational principle, Principle of least action. *(Lectures 7)*
4. **Canonical Transformation and Hamilton-Jacobi Theory:** Canonical transformation and its examples, Poisson's brackets, Equations of motion, Angular momentum, Poisson's Bracket relations, infinitesimal canonical transformation, Conservation Theorems. Hamilton- Jacobi equations for principal and characteristic functions, Action-angle variables for systems with one-degree of freedom. *(Lectures 10)*
5. **Rigid Body Motion:** Independent co-ordinates of rigid body, orthogonal transformations, Eulerian Angles and Euler's theorem, infinitesimal rotation, Rate of change of a vector, Coriolis force, angular momentum and kinetic energy of a rigid body, the inertia tensor, principal axis transformation, Euler equations of motion, Torque free motion of rigid body, motion of a symmetrical top. *(Lectures 10)*

Text Books:

1. Classical Mechanics: *H. Goldstein, C.Poole and J.Safko (Pearson Education Asia, New Delhi)*, 3rd ed 2001.
2. Mechanics by L.D. Landau & E.M. Lifschz (Pergamon), 1976.

Reference Books:

1. Classical Mechanics of Particles and Rigid Bodies: *K.C. Gupta (Wiley Eastern, New Delhi), 1988.*
2. Classical Mechanics- J. W. Muller- Kirsten (World Scientific) 2008.
3. Advanced Classical & Quantum Dynamics by W. Dittrich, W. And M Reuter, M. (Springer) 1991.
4. Classical mechanics by T.W.B. Kibble and Frank H. Berkshire (Imperial College Press) 2004.
5. Mathematical Methods of Classical Mechanics by V. I. Arnold, (Springer) 1978.

Instructions for End semester Paper-Setter in M. Sc. Physics

A. Scope

1. The question papers should be prepared strictly in accordance with the prescribed syllabus and pattern of question paper of the University.
2. The question paper should cover the entire syllabus uniformly covering each chapter thoroughly with proper distribution.
3. Each unit of course/syllabus carries weightage according to the number of lectures mentioned in syllabus. (1 Lecture ~ 2 Marks)
4. The language of questions should be simple, direct, and documented clearly and unequivocally so that the candidates may have no difficulty in appreciating the scope and purpose of the questions. The length of the expected answer should be specified as far as possible in the question itself.
5. The distribution of marks to each question/answer should be indicated in the question paper properly.

B. Type and difficulty level of question papers

1. Questions should be framed in such a way as to test the students intelligent grasp of broad principles and understanding of the applied aspects of the subject. The weightage of the marks as per the difficulty level of the question paper shall be as follows:
   - i) Easy question 30%
   - ii) Average questions 50%
   - iii) Difficult questions 20%
2. The numerical content of the question paper should be upto 20%.

C. Format of question paper

1. Paper code and Paper-ID should be mentioned properly.
2. The question paper will consist of three sections: Sections-A, B, and C.
3. Section-A is COMPULSORY consisting of TEN SHORT questions carrying two marks each (total 20 marks) covering the entire syllabus.
4. The Section-B consists of five questions of five marks each covering the entire syllabus.
5. The Section-C consists of THREE questions of ten marks each covering the entire syllabus.
6. Attempt any **FOUR** questions from Section-B and any **TWO** from Section-C.

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Question paper pattern for MST:

Roll No:	No of pages:

IK Gujral Punjab Technical University- Jalandhar	
Department of Physical Sciences	
Academic Session:	
Mid-Semester Test: I/II/III (Regular/reappear)	**Date:**
Programme: M.Sc. Physics	**Semester:**
Course Code:	**Course:**
Maximum Marks: 24	**Time: 1 hour 30 minutes**

❖ Note: Section A is compulsory; Attempt any two questions from Section B and one question from Section C.

Section: A		**Marks**	**COs**
1		2	
2		2	
3		2	
4		2	
Section: B			
5		4	
6		4	
7		4	
Section: C			
8		8	
9		8	

Details of Course Objectives

CO1	
CO2	
CO3	
CO4	
CO5	

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MSPH-414-21	Electronics	L-3, T-1, P-0	4 Credits

Pre-requisite: Basic knowledge about electronics

Course Objectives: The aim and objective of the course on **Electronics** is to introduce the students of M.Sc. class to the formal structure of the subject and to equip them with the knowledge of semiconductor physics, basic circuit analysis, first-order nonlinear circuits, OPAMP based analog circuits and introduction to digital electronics so that they can use these in various branches of physics as per their requirement.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand working of Different Semiconductor devices (Construction, Working Principles and V-I characteristics) and their applications.
CO2	Explain the construction and working of Thyristors and use Thyristors for various applications.
CO3	Design Analog and Digital Instruments and their applications.
CO4	Apply Boolean algebra and Karnaugh maps.
CO5	Design the Sequential and Integrated circuits.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	2	2	1	2	1	2	2	2
CO2	3	3	2	1	2	2	1	2	1	2	2	2
CO3	2	2	3	2	2	2	1	2	1	2	2	2
CO4	3	3	2	1	2	2	1	2	1	2	2	2
CO5	2	2	2	2	2	2	1	2	1	2	2	2

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MSPH-415-21	Computational Physics	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of graduate level physics

Course Objectives: The aim and objective of the course on **Computational Physics** is to familiarize the students of M.Sc. students with the numerical methods used in computation and programming using any high level language such as Fortran, C++, etc., so that they can use these in solving simple physics problems.

Course Outcomes: At the end of the course, the student will be able to

CO1	Apply basics knowledge of computational physics in solving the physics problems.
CO2	Programme with the C++ or any other high level language.
CO3	Use various numerical methods in solving physics problems.
CO4	Analyze the outcome of the algorithm/program graphically.
CO5	Simulate the physical systems using simulations.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	1	2	3	2	3	2
CO2	3	3	3	1	2	1	1	1	3	2	3	2
CO3	3	3	3	2	2	1	1	2	1	2	2	2
CO4	3	3	3	3	2	2	2	2	2	2	2	2
CO5	3	3	3	3	2	2	1	2	2	2	2	2

Detailed Syllabus:

1. **Introduction to Computational Physics:** Need and advantages of high level language in physics, programming in a suitable high level language, input/output, interactive input, loading and saving data, loops branches and control flow, Matrices and Vectors, Matrix and array operations, need for Graphic tools. *(Lectures 11)*

2. **Programming with C++:** Introduction to the Concept of Object Oriented Programming; Advantages of C++ over conventional programming languages; Introduction to Classes, Objects; C++ programming syntax for Input/Output, Operators, Loops, Decisions, simple and inline functions, arrays, strings, pointers; some basic ideas about memory management in C+. *(Lectures 15)*

3. **Numerical methods:** Computer algorithms, interpolations-cubic spline fitting, Numerical differentiation – Lagrange interpolation, Numerical integration by Simpson and Weddle's rules, Random number generators, Numerical solution of differential equations by Euler, predictor-corrector and Runge-Kutta methods, eigenvalue problems, Monte Carlo simulations. *(Lectures 15)*

Text Books:

1. Numerical Mathematical Analysis, J.B. Scarborough (Oxford & IBH Book Co.) 6th ed., 1979.
2. A first course in Computational Physics: P.L. DeVries (Wiley) 2nd edition, 2011.

Reference Books:

1. Computer Applications in Physics: S. Chandra (Narosa) 2nd edition, 2005.
2. Computational Physics: R.C. Verma, P.K. Ahluwalia and K.C. Sharma (New Age) 2000.
3. Object Oriented Programming with C++: Balagurusamy, (Tata McGraw Hill) 4th edition 2008.

MSPH-416-21	Electronics Lab	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of graduate level physics electronics experiments

Course Objectives: The aim and objective of the laboratory on **Electronics Lab** is to expose the students of M.Sc. class to experimental techniques in electronics so that they can verify some of the things read in theory here or in earlier classes and develop confidence to handle sophisticated equipment.

Course Outcomes: At the end of the course, the student will

CO1	Acquire hands on experience of handling and building electronics circuits.
CO2	Be familiar with the various components such as resistors, capacitor, inductor, IC chips and how to use these components in circuits.
CO3	Be able to understand the construction, working principles and V-I characteristics of various devices such as PN junction diodes, UJT, TRIAC, etc.
CO4	Capable of using components of digital electronics for various applications.
CO5	Able to design and perform scientific experiments as well as accurately record and analyze the results of experiments.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	1	2	1	2	2	2	2	2
CO2	2	1	2	2	2	2	1	2	2	2	2	2
CO3	1	1	2	2	1	1	1	2	2	2	2	2
CO4	2	2	2	2	2	3	1	2	2	2	2	2
CO5	3	2	3	3	2	3	1	2	2	2	2	2

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MSPH-413-21	**Quantum Mechanics-I**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: Basic knowledge of wave mechanical quantum mechanics			
Course Objectives: The aim and objective of the course on **Quantum Mechanics-I** is to introduce the students of M.Sc. class to the formal structure of the subject and to equip them with the techniques of vector spaces, angular momentum, perturbation theory, and scattering theory so that they can use these in various branches of physics as per their requirement.			
Course Outcomes: At the end of the course, the student will be able to			

CO1	Understand the need for quantum mechanical formalism and its basic principles.
CO2	Appreciate the importance and implication of vector spaces, Dirac ket bra notations, eigen value problem.
CO3	Understand the implications of generalized uncertainty principle in QM.
CO4	Better understanding of the mathematical foundations of spin and angular momentum for a system of particles.
CO5	Solve Schrodinger equation for various QM systems using approximate methods.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	2	1	1	2	3	2	2
CO2	3	2	2	2	2	2	1	1	2	2	2	2
CO3	3	2	2	2	2	2	1	2	1	3	2	2
CO4	3	2	2	2	2	2	2	2	2	2	2	2
CO5	3	2	2	2	2	2	1	1	2	3	2	2

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Detailed Syllabus:

1. **Linear Vector Space and Matrix Mechanics:** Vector spaces, Schwarz inequality, Orthonormal basis, Operators: Projection operator, Hermitian and Unitary operators, change of basis, Eigenvalue and Eigenvectors of operators, Dirac's bra and ket notation, commutators, Simultaneous eigenvectors, Postulates of quantum mechanics, uncertainty relation, Harmonic oscillator in matrix mechanics, Time development of states and operators, Heisenberg, Schroedinger and Interaction representations, Exchange operator and identical particles, Density Matrix and Mixed Ensemble. *(Lectures 15)*

2. **Angular Momentum:** Angular part of the Schrödinger equation for a spherically symmetric potential, orbital angular momentum operator. Eigen values and eigenvectors of L^2 and Lz. Spin angular momentum, General angular momentum, Eigen values and eigenvectors of J^2 and Jz. Representation of general angular momentum operator, Addition of angular momenta, C.G. coefficients. *(Lectures 10)*

3. **Stationary State Approximate Methods:** Non-Degenerate and degenerate perturbation theory and its applications, Variational method with applications to the ground states of harmonic oscillator and other sample systems. *(Lectures 8)*

4. **Time Dependent Perturbation:** General expression for the probability of transition from one state to another, constant and harmonic perturbations, Fermi's golden rule and its application to radiative transition in atoms, Selection rules for emission and absorption of light. *(Lectures 7)*

Text Books:

1. A Text book of Quantum Mechanics: P.M. Mathews and K. Venkatesan (Tata McGraw Hill, New Delhi) 2nd edition, 2004.
2. Quantum Mechanics: V.K. Thankappan (New Age, New Delhi), 2004.

Reference Books:

1. Quantum Mechanics: M.P. Khanna (Har Anand, New Delhi), 2006.
2. Modern Quantum Mechanics: J.J. Sakurai (Addison Wesley, Reading), 2004.
3. Quantum Mechanics: J.L. Powell and B. Crasemann (Narosa, New Delhi), 1995.
4. Quantum Physics: S. Gasiorowicz (Wiley, New York), 3rd ed. 2002.
5. Quantum Physics: Concepts and Applications: Nouredine Zettili (Wiley, New York), 2nd ed. 2009.

Detailed Syllabus:

Note: Students are expected to perform atleast 10 experiments out of following list.

1. Study the forward and reverse characteristics of a Semiconctor/Zener diode.
2. Construction of adder, subtracter, differentiator and integrator circuits using the given OP-Amp.
3. Study the static and drain characteristics of a JFET.
4. Construction of an Astable multivibrator circuit using transistor.
5. Construction of a single FET amplifier with common source configuration.
6. To study the operation of Analog to Digital convertor.
7. To study the operation of Digital to Analog convertor.
8. Construction of a low-pass filter circuit and study its output performance.
9. Construction of a high-pass filter circuit and study its output performance.
10. To verify the Dmorgan's law using Logic Gates circuit.
11. To study the Characteristics of Tunnel Diode.
12. To study Amplitude Modulation.
13. To study Frequency Modulation.
14. To study the Characteristics of SCR.
15. To study the Characteristics of MOSFET.
16. To study the Characteristics of UJT.
17. To study the Characteristics of TRIAC.
18. To verify the different Logic and Arithmetic operations on ALU system.
19. To study the operation of Encoders and Decoders.
20. To study the operation of Left and right shift registers.
21. To study the operation of Counters, Ring counters.
22. To determine the thermal coefficient of a thermistor.
23. To study the operation of an Integrated Circuit Timer.

Text Books:

1. Text Book of Electronics: *S. Chattopadhyay,* New Central Book Agency P.Ltd., Kolkata, 2006.
2. Digital Principles and Applications: *A.P. Malvino and D.P. Leach,* Tata McGraw-Hill, Publishing Co., New Delhi.

Reference Books:

1. Electronics Principles and Applications: *A.B. Bhattacharya*, New Central Book Agency P.Ltd., Kolkata, 2007.
2. Integrated Electronics Analog and Digital Circuits and Systems: *J. Millman, C.C Halkins and C. Parikh*, 2nd Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2010.

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MSPH-417-21	Computational Physics Lab-I	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of graduate level numerical methods

Course Objectives: The aim and objective of the course on **Computational Physics Lab-I** is to familiarize the of M.Sc. students with the numerical methods used in computation and programming using C++ language so that they can use these in solving simple problems pertaining to physics.

Course Outcomes: At the end of the course, the student will be able to

CO1	Apply basics knowledge of computational Physics in solving various physical problems.
CO2	Programme with the C++ or any other high level language.
CO3	Use various numerical methods in describing/solving physics problems.
CO4	Solve problem, critical thinking and analytical reasoning as applied to scientific problems.
CO5	Analyse and reproduce the experimental data.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	1	2	3	2	3	2
CO2	3	3	3	1	2	1	1	1	3	2	3	2
CO3	3	3	3	2	2	1	1	2	1	2	2	2
CO4	3	3	2	2	3	1	1	1	1	1	1	1
CO5	1	3	3	3	1	1	1	1	2	1	2	2

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Detailed Syllabus:

Note: Students are expected to perform atleast 10 experiments out of following list using C++ and Gnuplot.

1. To find the standard deviation, mean, variance, moments etc. of at least 15 entries.
2. To choose a set of 10 values and find the least squared fitted curve.
3. Find y for a given x by fitting a set of values with the help of cubic spline fitting technique.
4. To find the Roots of an Algebraic Equation by Bisection method and secant method
5. To find the Roots of an Algebraic Equation by Newton-Raphson Method.
6. To find the Roots of Linear Equations by Gauss Elimination Method.
7. To find the Roots of Linear Equations by Gauss-Seidal Iterative Method.
8. Find first order derivative at given x for a set of values with the help of Lagrange interpolation.
9. To perform numerical integration of a function by Trapezoidal Rule.
10. To perform numerical integration of a function by Simpson's Rule.
11. To perform numerical integration of a function by Weddle's rule.
12. To solve a Differential Equation by Euler's method and Modified Euler's Method.
13. To solve a Differential Equation by Runge Kutta method.
14. To find the determinant of a matrix and its eigenvalues and eigenvectors.
15. To generate random numbers between (i) 1 and 0, (ii) 1 and 100.

Text Books:

1. Numerical Mathematical Analysis, J.B. Scarborough (Oxford & IBH Book Co.) 6th ed., 1979.
2. A first course in Computational Physics: P.L. DeVries (Wiley) 2nd edition, 2011.

Reference Books:

1. Computer Applications in Physics: S. Chandra (Narosa) 2nd edition, 2005.
2. Computational Physics: R.C. Verma, P.K. Ahluwalia and K.C. Sharma (New Age) 2000.
3. Object Oriented Programming with C++: Balagurusamy, (Tata McGrawHill) 4th edition 2008.

MSPH-421-21	Mathematical Physics-II	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of graduate level mathematics

Course Objectives: The aim and objective of the course on **Mathematical Physics-II** is to equip the M.Sc. Students with the mathematical techniques that he/she needs for understanding theoretical treatment in different courses taught in this class and for developing a strong background if he/she chooses to pursue research in physics as a career.

Course Outcomes: At the end of the course, the student will able to

CO1	Understand the basics and aplications of group theory in all the branches of Physics.
CO2	Use Fourier series and transformations as an aid for analyzing physical problems.
CO3	Apply integral transform to solve mathematical problems of Physics interest.
CO4	Formulate and express a physical law in terms of tensors and simplify it by use of coordinate transforms.
CO5	Develop mathematical skills to solve quantitative problems in physics.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	-	1	1	-	2	1	1	2
CO2	3	3	2	2	-	1	1	-	2	1	1	2
CO3	3	3	2	2	-	1	1	-	2	1	1	2
CO4	3	3	2	2	-	1	1	-	2	1	1	2
CO5	3	3	2	2	-	1	1	-	2	1	1	2

Detailed Syllabus:

1. **Group Theory:** What is a group? Multiplication table, conjugate elements and classes, subgroups, Isomorphism and Homomorphism, Definition of representation and its properties, Reducible and irreducible representations, Schur's lemmas (only statements), characters of a representation. Example of C4v, Topological groups and Lie groups, three dimensional rotation group, special unitary groups SU(1) and SU(2). *(Lectures 10)*

2. **Tensors:** Introduction, definitions, contraction, direct product. Quotient rule, Levi-Civita symbol, Noncartesian tensors, metric tensor, Covariant differentiation. *(Lectures 7)*

3. **Fourier Series and Integral Transforms:** Fourier series, Dirichlet conditions, General properties, Advantages and applications, Gibbs phenomenon, Fourier transforms, Development of the Fourier integral, Inversion theorem, Fourier transforms of derivatives; Momentum representation. Laplace transforms, Laplace transforms of derivatives, Properties of Laplace transform, Inverse Laplace transformation. *(Lectures 15)*

4. **Integral Equations:** Definitions and classifications, integral transforms and generating functions. Neumann series, Separable Kernels, Hilbert-Schmidt theory, Green's functions in one dimension. *(Lectures 10)*

Text Books:

1. Group Theory for Physicists: A.W. Joshi (Wiley Eastern, New Delhi) 2011.
2. Mathematical Methods for Physicists: G. Arfken and H.J. Weber, (Academic Press, San Diego) 7th edition, 2011.

Reference Books:

1. Matrices and Tensors in Physics: A.W. Joshi (Wiley Eastern, New Delhi) 2005.
2. Numerical Mathematical Analysis: J.B. Scarborough (Oxford Book Co., Kolkata) 4th edition.
3. A First Course in Computational Physics: P.L. Devries (Wiley, New York) 1994.
4. Mathematical Physics: P.K. Chatopadhyay (Wiley Eastern, New Delhi) 2011.
5. Introduction to Mathematical Physics: C. Harper (Prentice Hall of India, New Delhi) 2006.

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MSPH-422-21	**Statistical Mechanics**	**L-3, T-1, P-0**	**4 Credits**

Pre-requisite: Understanding of graduate level statistical mechanics

Course Objectives: The aim and objective of the course on **Statistical Mechanics** is to equip the M.Sc. student with the techniques of statistical ensemble theory so that he/she can use these to understand the macroscopic properties of the matter in bulk in terms of its microscopic constituents.

Course Outcomes: At the end of the course, the student will be able to

CO1	Find the connection between Statistical Mechanics and thermodynamics
CO2	Use ensemble theory to explain the behavior of Physical systems
CO3	Explain the statistical behavior of Bose-Einstein and Fermi-Dirac systems and their applications.
CO4	Work with models of phase transitions and thermo-dynamical fluctuations.
CO5	Describe physical problems using quantum statistics.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	1	-	-	-	-	-	1	1	-	-	-
CO2	3	3	3	1	3	2	1	2	2	1	1	1
CO3	3	3	3	1	2	2	1	2	2	1	1	1
CO4	3	3	3	1	2	2	1	2	2	1	1	1
CO5	3	3	3	1	2	2	1	2	2	1	1	1

Detailed Syllabus:

1. **The Statistical Basis of Thermodynamics:** The macroscopic and microscopic states, contact between statistics and thermodynamics, classical ideal gas, Gibbs paradox and its solution. *(Lectures 7)*

2. **Ensemble Theory:** Phase space and Liouville's theorem, the microcanonical ensemble theory and its application to ideal gas of monatomic particles; The canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations, equipartition and virial theorems, a system of quantum harmonic oscillators as canonical ensemble, statistics of paramagnetism; The grand canonical ensemble and significance of statistical quantities, classical ideal gas in grand canonical ensemble theory, density and energy fluctuations. *(Lectures 10)*

3. **Quantum Statistics of Ideal Systems:** Quantum states and phase space, an ideal gas in quantum mechanical ensembles, statistics of occupation numbers; Ideal Bose systems: basic concepts and thermodynamic behaviour of an ideal Bose gas, Bose-Einstein condensation, discussion of gas of photons (the radiation fields) and phonons (the Debye field); Ideal Fermi systems: thermodynamic behaviour of an ideal Fermi gas, discussion of heat capacity of a free electron gas at low temperatures, Pauli paramagnetism. *(Lectures 10)*

4. **Elements of Phase Transitions:** Introduction, a dynamical model of phase transitions, Ising model in zeroth approximation. *(Lectures 8)*

5. **Fluctuations:** Thermodynamic fluctuations, random walk and Brownian motion, introduction to non-equilibrium processes, diffusion equation. *(Lectures 5)*

Text Books:

1. Statistical Mechanics: R.K. Pathria and P.D. Beale (Butterworth-Heinemann, Oxford), 3rd edition, 2011.

Reference Books:

1. Statistical Mechanics: *K. Huang (Wiley Eastern, New Delhi), 1987.*
2. Statistical Mechanics: *B.K. Agarwal and M. Eisner (Wiley Eastern, New Delhi) 2nd edition, 2011.*
3. Elementary Statistical Physics: *C. Kittel (Wiley, New York), 2004.*
4. Statistical Mechanics: *S.K. Sinha (Tata McGraw Hill, New Delhi), 1990.*

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MSPH-423-21	Quantum Mechanics–II	L-3, T-1, P-0	4 Credits

Pre-requisite: Preliminary course of Quantum Mechanics

Course Objectives: The aim and objective of the course on **Quantum Mechanics-II** is to introduce the M.Sc. students to the formal structure of the subject and to equip him/her with the techniques of Relativistic quantum mechanics and Quantum field theory so that he/she can use these in various branches of physics as per his/her requirement.

Course Outcomes: At the end of the course, the student will be able to

CO1	Define the relativistic QM as the covariant formulation of quantum mechanics and need for quantum field theory
CO2	Give the significance of Klein Gordon and Dirac equation and explain the existence of antiparticles.
CO3	Apply the symmetries principles and Noether's theorem in calculating the conserved currents and charges.
CO4	Demonstrate the second quantization for scalar, Dirac, and electromagnetic fields.
CO5	Explain the origin of Feynman diagrams and apply the Feynman rules to derive the amplitudes for elementary processes.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	1	1	1	2	2	1	2	2
CO2	2	2	3	1	1	1	-	1	2	1	2	2
CO3	2	2	2	2	1	1	1	1	2	1	2	2
CO4	2	2	2	2	1	1	1	2	2	1	2	2
CO5	2	2	3	2	1	1	2	2	2	1	2	2

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Detailed Syllabus:

1. **Relativistic Quantum Mechanics-I:** Klein-Gordon equation, Dirac equation and its plane wave solutions, significance of negative energy solutions, spin angular momentum of the Dirac particle, the non-relativistic limit of Dirac equation.

   (Lectures 10)

2. **Relativistic Quantum Mechanics-II:** Electron in electromagnetic fields, spin magnetic moment, spin-orbit interaction, Dirac equation for a particle in a central field, fine structure of hydrogen atom, Lamb shift.

   (Lectures 10)

3. **Quantum Field Theory:** Resume of Lagrangian and Hamiltonian formalism of a classical field, Noether theorem, Quantization of real scalar field, complex scalar field, Dirac field and electromagnetic field, Covariant perturbation theory, Wick's theorem, Scattering matrix. *(Lectures 10)*

4. **Feynman diagrams**: Feynman rules, Feynman diagrams and their applications, Yukawa field theory, calculations of scattering cross-sections, decay rates with examples, Quantum Electrodynamics, calculations of matrix elements - for first order and second order.

   (Lectures 10)

Text Books:

1. Relativistic quantum Mechanics, J D Bjorken and S D Drell, (Tata McGraw Hill, New Delhi) 2012.
2. A first book of Quantum Field Theory, A. Lahiri & P. Pal, (Narosa Publishers, New Delhi), 1st ed. 2005.
3. Introduction to Quantum Field Theory, M. Peskin & D.V. Schroeder. (Levant Books) 2015.

Reference Books:

1. Quantum Field Theory in a Nutshell: A Zee (University Press), 2012.
2. *Lecture on Quantum Field Theory, A. Das (World Scientific), 2008.*
3. Text Book of Quantum Mechanics-*P.M. Mathews & K. Venkatesan (Tata McGraw Hill, New Delhi), 2004.*
4. Quantum Field Theory: H. Mandl and G. Shaw *(Wiley, New York*), 2010.
5. Advance Quantum Mechanics: J.J. Sakurai *(Addison- Wesley, Reading*), 2004.

MSPH-424-21	**Classical Electrodynamics**	**L-3, T-1, P-0**	**4 Credits**

Pre-requisite: Understanding of graduate level electricity and magnetism

Course Objectives: The **Classical Electrodynamics** course covers Electrostatics and Magnetostatics including Maxwell equations, and their applications to propagation of electromagnetic waves in dielectrics; EM waves in bounded media, waveguides, Radiation from time varying sources.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the concept of quadrupole, multipole expansion and dielectric polarization.
CO2	Explain the magnetic scalar, vector potential and boundary conditions on magnetic fields.
CO3	Provide solution to various boundary value problems.
CO4	Use Maxwell equations in different forms and different media and describe the propagation of electromagnetic waves through different media.
CO5	Develop analytical skills to solve problems related to propagation of EM waves through wave guides.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	2	1	2	1	1	1	2	3
CO2	2	2	1	1	1	1	1	1	1	3	2	3
CO3	2	2	2	2	2	2	1	1	1	2	2	3
CO4	2	2	1	2	1	2	1	1	1	3	2	3
CO5	1	2	1	2	1	1	1	2	2	3	2	3

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Detailed Syllabus:

1. **Electrostatics:** Electrostatic potential and potential of a charge distribution, dipole moment, Electric Quadrupole and multipoles, Multipole expansion of the scalar potential, Dielectric polarization and its types, Polarization vector, Relation between electric displacement, electric field and Polarisation, Electrostatic energy and energy density in free space and dielectric, Boundary conditions at the interface of two dielectrics. *(Lectures 10)*
2. **Magnetostatics:** Current density, magnetic induction, Force on a current element: Ampere's Force law, Divergence of magnetic induction, Magnetic scalar and vector potential, Boundary conditions on magnetic fields. *(Lectures 6)*
3. **Boundary value problems:** Uniqueness theorem, Green's theorem, Green's reciprocation theorem, Solution of electrostatic boundary value problem with Green function, Method of images with examples; Point charge near an infinite grounded conducting plane; Dielectric slab of infinite face in front of a point charge, Laplace and Poisson's equations in different coordinates, Solution of Laplace equation. *(Lectures 8)*
4. **Maxwell equations and Electromagnetic Waves:** Maxwell equations, Concept of displacement current, Maxwell's equations for free space, static fields and in Phasor notation, Wave equations in free space, non-conducting and conduction medium (Phasor form), Propagation characteristics of EM waves in free space, non-conducting and conducting media, conductors and dielectrics, depth of penetration, Poynting vector, Poynting theorem, Poynting theorem in complex form, Polarisation, Reflection of waves by a perfect conductor-normal and oblique incidence, Reflection and transmission of waves by a perfect dielectric-normal and oblique incidence, Brewster's angle, Total internal reflection, Gauge transformation, Lorentz and Coulomb gauges, Hertz potential, *(Lectures 10)*
5. **Wave Guides:** Wave guides, Derivation of field equations in rectangular wave guides, Transverse magnetic (TM) waves, Transverse Electric (TE) waves, Propagation characteristics of TM and TE waves, Lowest possible mode in TM and TE waves, Dominant mode, Evanescent mode, Degenerate mode, Transverse electromagnetic (TEM) waves and characteristics, Difference between Transmission lines and wave guides, Definition, function and properties of an antenna, Retarded vector potential . *(Lectures 10)*

Text Books:

1. Classical Electrodynamics: *S.P. Puri (Narosa Publishing House) 2011.*
2. Classical Electrodynamics: *J.D. Jackson, (New Age, New Delhi) 2009.*
3. Introduction to Electrodynamics: *D.J. Griffiths (Prentice Hall India, New Delhi) 4th ed., 2011.*

Reference Books:

1. Classical Electromagnetic Radiation: *J.B. Marion and M.A. Heald(Saunders College Publishing House) 2nd edition, 1995.*
2. Electromagnetic Fields, *Ronald K. Wangsness (John Wiley and Sons) 2nd edition,1986.*
3. Electromagnetic Field Theory Fundamentals: *Bhag Singh Guru and H.R. Hiziroglu*

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MSPH-425-21	Atomic and Molecular Physics	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of graduate level spectroscopy

Course Objectives: The aim and objective of the course on **Atomic and Molecular Physics** for the students of M.Sc. Physics is to equip them with the knowledge of Atomic, Rotational, Vibrational, Raman, and Electronic spectra.

Course Outcomes: At the end of the course, the student will be able to

CO1	Have the basic knowledge of Bohr's- Sommerfeld Quantum theory of hydrogen like atom
CO2	Understand classical/quantum description of electronic spectra of atom and molecules
CO3	Use microwave and Raman Spectroscopy for analysis of known molecules
CO4	Correlate infrared spectroscopic information of known molecules with their physical description
CO5	Understand Spin Resonance Spectroscopy with focus on NMR for molecular analysis

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	2	2	1	1	2	2	3	1	2
CO2	2	2	3	3	2	1	2	2	2	3	1	1
CO3	2	2	3	3	2	1	2	2	2	3	1	3
CO4	2	2	3	3	2	1	2	2	2	3	1	3
CO5	2	2	3	3	2	1	2	2	2	3	1	3

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Detailed Syllabus:

1. **Electronic Spectroscopy of Atoms:** Bohr-Sommerfeld model of atomic structure, Electronic wave function and atomic quantum numbers – hydrogen spectrum – orbital, spin and total angular momentum - fine structure of hydrogen atom – many electron spectrum: Lithium atom spectrum, angular momentum of many electrons – term symbols – the spectrum of helium and alkaline earths – equivalent and non-equivalent electrons –X-ray photoelectron spectroscopy. *(Lectures 8)*
2. **Electronic Spectroscopy of Molecules:** Diatomic molecular spectra: Born-Oppenheimer approximation – vibrational spectra and their progressions – Franck-Condon principle – dissociation energy and their products –rotational fine structure of electronic-vibration transition - molecular orbital theory – the spectrum of molecular hydrogen – change of shape on excitation – chemical analysis by electronic spectroscopy – reemission of energy – fundamentals of UV photoelectron spectroscopy. *(Lectures 9)*
3. **Microwave and Raman Spectroscopy:** Rotation of molecules and their spectra – diatomic molecules – intensity of line spectra – the effect of isotropic substitution – non-rigid rotator and their spectra – polyatomic molecules (linear and symmetric top molecules) – Classical theory of Raman effect - pure rotational Raman spectra (linear and symmetric top molecules). *(Lectures 8)*
4. **Infra-red and Raman Spectroscopy:** The energy of diatomic molecules – Simple Harmonic Oscillator - the Anharmonic oscillator– the diatomic vibrating rotator – vibration-rotation spectrum of carbon monoxide –breakdown of Born-Oppenheimer approximation – the vibrations of polyatomic molecules –influence of rotation on the spectra of polyatomic molecules (linear and symmetric top molecules) – Raman activity of vibrations – vibrational Raman spectra – vibrations of Spherical top molecules. *(Lectures 8)*
5. **Spin Resonance Spectroscopy** Spin and magnetic field interaction – Larmor precession – relaxation time – spin-spin relaxation - spin–lattice relaxation - NMR chemical shift - coupling constants – coupling between nuclei – chemical analysis by NMR – NMR for nuclei other than hydrogen – ESR spectroscopy - fine structure in ESR. *(Lectures 8)*

Text Books:

1. Fundamentals of Molecular Spectroscopy: Colin N. Banwell and Elaine M. McCash (Tata McGraw-Hill Publishing Company limited).
2. Physics of Atoms and Molecules: B. H. Bransden and C. J. Joachain.

Reference Books:

1. Physical method for Chemists (Second Edition):*Russell S. Drago (Saunders College Publishing).*
2. Introduction to Atomic Spectra: *H.E. White-Auckland McGraw Hill, 1924.*
3. Spectroscopy Vol. I, II & III: *Walker & Straughen*
4. Introduction to Molecular spectroscopy: *G.M. Barrow-Tokyo McGraw Hill, 1961.*
5. Spectra of diatomic molecules: *Herzberg-New York, 1944.*

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MSPH-426-21	Atomic, Nuclear, and Particle Physics Lab	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of graduate level atomic spectroscopy and nuclear physics

Course Objectives: The aim and objective of the lab on **Atomic, Nuclear and Particle Physics** is to expose the students of M.Sc. students to experimental techniques in atomic and nuclear physics so that they can verify some of the results obtained in theory and develop confidence to handle sophisticated equipment.

Course Outcomes: At the end of the course, the student will be able to

CO1	Acquire hands on experience of using particle detectors such as GM counter and Scintillation counter.
CO2	Handle oscilloscope for visualisation of various input and output signals.
CO3	Understand the basic of nuclear safely management.
CO4	Perform scientific experiments as well as accurately record and analyze the results of nuclear experiments.
CO5	Solve applied nuclear problems with critical thinking and analytical reasoning.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	1	2	2	2	2	2	2	2
CO2	1	1	1	2	1	2	1	2	2	2	2	2
CO3	1	1	1	2	1	2	1	2	2	2	2	2
CO4	1	2	2	2	1	2	2	2	2	2	2	2
CO5	1	2	2	2	1	2	2	2	2	2	2	2

Detailed Syllabus:

Note: Students are expected to perform atleast 10 experiments out of following list.

1. Determination of e/m of electron by Normal Zeeman Effect using Febry Perot interferometer.
2. To verify the existence of Bohr's energy levels with Frank-Hertz experiments.
3. Determination of Lande's factor of DPPH using Electron-spin resonance (E.S.R.) spectrometer.
4. Determination of ionization Potential of Lithium.
5. Analysis of pulse height of gamma ray spectra.
6. To study the characteristics of G.M. tube.
7. To verify the inverse square law using GM counter.
8. To determine the dead time of G.M. counter.
9. To study absorption of beta particles is matter using GM counter.
10. To study Gaussian distribution using G.M. counter.
11. To estimate the efficiency of GM detector for Gamma and Beta source.
12. Determination of Planck's constant using Photocell and interference filters.
13. Verification of Inverse square law using Photocell.
14. To study Gaussian distribution using scintillation counter.
15. To study absorption of gamma radiation by scintillation counter.
16. To estimate the efficiency of Scintillator counter.

Text Books:

1. Fundamentals of Molecular Spectroscopy: *Colin N. Banwell and Elaine M. McCash (Tata McGraw-Hill Publishing Company limited).*
2. Physics of Atoms and Molecules: *B. H. Bransden and C. J. Joachain.*

Reference Books:

1. Physical method for Chemists (Second Edition): *Russell S. Drago (Saunders College Publishing).*
2. Introduction to Atomic Spectra: *H.E. White-Auckland McGraw Hill, 1924.*
3. Spectroscopy Vol. I, II & III: *Walker & Straughen*
4. Introduction to Molecular spectroscopy: *G.M. Barrow-Tokyo McGraw Hill, 1961.*
5. Spectra of diatomic molecules: *Herzberg-New York, 1944.*

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MSPH-427-21	Computational Physics Lab-II	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of graduate level numerical methods and C++

Course Objectives: The aim and objective of the lab on **Computational Physics-II** is to train the students of M.Sc. class in understanding numerical methods, the usage of high level language such as C++ language for simulation of results for different physics problems and graphic analysis of physical data, so that they are well equipped in the use of computer for solving physics related problems.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand and apply basics knowledge of numerical methods in solving the Physics problems.
CO2	Write programme with the C++ or any other high level language.
CO3	Learn use of graphical methods in data analysis and solving physics problems.
CO4	Solve physical problem, enabling development of critical thinking and analytical reasoning.
CO5	Apply computational physics in frontier areas of pure and applied research in physics and allied fields.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	2	1	1	1	3	2	3	2
CO2	3	3	3	2	2	1	1	2	1	2	2	2
CO3	1	2	1	3	1	2	1	1	1	1	1	1
CO4	3	3	2	2	3	1	1	1	1	1	1	1
CO5	1	1	1	1	1	1	1	1	3	2	1	1

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Detailed Syllabus:

Note: Students are expected to perform atleast 10 experiments out of following list using C++ and Gnuplot.

1. Write a program to study graphically the EM oscillations in LCR circuit (use Runge-Kutta Method). Show the variation of (i) Charge vs Time and (ii) Current vs Time.
2. Study graphically the motion of falling spherical body under various effects of medium (viscous drag, buoyancy and air drag) using Euler method.
3. Study graphically the path of a projectile with air drag using FN method. Find the horizontal and maximum height in either case. Write your comments on the findings.
4. Study graphically the path of a projectile without air drag using FN method. Find the horizontal and maximum height in either case. Write your comments on the findings.
5. Study the motion of an artificial satellite.
6. Study the motion of 1-D harmonic oscillator (without and with damping effects). Draw graphs showing the relations: i) Velocity vs Time, ii) Acceleration vs Time iii) Position vs Time, also compare the numerical and analytical results.
7. Study the motion of two coupled harmonic oscillators. Draw graphs showing the relations: i) Velocity vs Time, ii) Acceleration vs Time iii) Position vs Time, also compare the numerical and analytical results.
8. To obtain the energy eigenvalues of a quantum oscillator using the Runge-Kutta method.
9. Study the motion of a charged particle in uniform electric field.
10. Study the motion of a charged particle in uniform Magnetic field.
11. Study the motion of a charged particle in combined uniform electric and magnetic fields.
12. Use Monte Carlo techniques to simulate phenomenon of Nuclear Radioactivity. Do the cases in which the daughter nuclei are also unstable with half life greater/lesser than the parent nucleus.
13. Use Monte Carlo techniques to simulate phenomenon to determine solid angle in a given geometry.
14. Use Monte Carlo techniques to simulate phenomenon to simulate attenuation of gamma rays/neutron in an absorber.
15. Use Monte Carlo techniques to simulate phenomenon to solve multiple integrals and compare results with Simpson's method.

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16. To study phase trajectory of a Chaotic Pendulum.

17. To study convection in fluids using Lorenz system.

Text Books:

1. Numerical Recipes in C++ The Art of Scientific Computing, William H. Press, Saul, A.Teukolsky, William T. Vetterling, and Brian P. Flannery, (Cambridge), 2nd ed. 2001.
2. A First Course in Computational Physics: P.L. DeVries (John Wiley) 2000.

Reference Books:

1. An introduction to Computational Physics: Tao Pang (Cambridge), 2nd ed. 2006.
2. Computer Applications in Physics: S. Chandra (Narosa), 2006.
3. Computational Physics: R.C. Verma, P.K. Ahluwalia and K.C. Sharma (New Age), 2005.
4. Object Oriented Programming with C++: Balagurusamy, (Tata McGraw Hill), 5th ed. 2011.

MSPH-531-21	**Condensed Matter Physics**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: Understanding of graduate level solid state physics			
Course Objectives: The aim and objective of the course on **Condensed Matter Physics** is to expose the students of M.Sc. class to the topics like elastic constants, lattice vibrations, dielectric properties, energy band theory and transport theory so that they are equipped with the techniques used in investigating these aspects of the matter in condensed phase.			
Course Outcomes: At the end of the course, the student will be able to			

CO1	Gain in-depth knowledge about the formation of various crystal structure via performing calculations on their elemental parameters.
CO2	Differentiate between various lattice types based on their lattice dynamics and then explain thermal properties of crystalline solids.
CO3	Understand the electron motion in periodic solids and origin of energy bands in semiconductors.
CO4	To explain the basic transport theory for understanding the transport phenomenon in solids
CO5	Using various models of molecular polarizability, understand the dielectric properties of insulators.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1	2	1	2	2	2	1	2
CO2	2	2	2	2	2	2	2	2	2	2	2	2
CO3	2	2	1	2	1	2	2	2	1	2	1	2
CO4	2	2	1	2	2	2	1	2	1	2	2	2
CO5	2	1	1	2	2	2	2	2	1	2	2	2

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MSPH-532-21	Nuclear Physics	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of graduate level physics

Course Objectives: The aim and objective of the course on **Nuclear Physics** is to familiarize the students of M.Sc. class to the basic aspects of Nuclear Physics like static properties of nuclei, radioactive decays, nuclear forces, nuclear models, and nuclear reactions so that they are equipped with the techniques used in studying these things.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand and compare nuclear models and explain nuclear properties using nuclear models.
CO2	Understand structure and static properties of nuclei.
CO3	Analyse various decay mode of nucleus.
CO4	Use nucleon-nucleon scattering and deuteron problem to explain nature of nuclear forces.
CO5	Describe various types of nuclear reactions and their properties.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	1	2	1	1	2	1	2	2	2
CO2	3	3	1	1	2	1	1	2	1	2	2	2
CO3	3	3	1	1	2	1	1	2	1	2	2	2
CO4	3	3	1	1	2	1	1	2	1	2	2	2
CO5	3	3	1	1	2	1	1	2	1	2	2	2

Detailed Syllabus:

1. **Static properties of nucleus:** Nuclear radii and measurements, nuclear binding energy (review), nuclear moments and systematic, wave-mechanical properties of nuclei, hyperfine structure. *(Lectures 5)*

2. **Nuclear forces:** Evidence for saturation of nuclear density and binding energies (review), types of nuclear potential, Ground and excited states of deuteron, dipole and quadrupole moment of deuteron, single and triplet potentials, meson theory of nuclear forces. *(Lectures 10)*

3. **Nuclear decay:** Review of barrier penetration of alpha decay & Geiger-Nuttal law. Beta decays, Fermi theory, Kurie plots and comparative half-lives, Allowed and forbidden transitions, Experimental evidence for Parity-violation in beta decay, Electron capture probabilities, Neutrino, detection of neutrinos, Multipolarity of gamma transitions, internal conversion process. *(Lectures 10)*

4. **Nuclear Models:** Liquid drop model, Binding energy; fission and fusion, Experimental evidence for shell effects, Shell Model, Spin-Orbit coupling, Magic numbers, Application of Shell Model like Angular momenta and parities of nuclear ground states, Collective model-nuclear vibrations spectra and rotational spectra. *(Lectures 8)*

5. **Nuclear reactions:** Nuclear reactions and cross-sections, Resonance, Breit- Wigner dispersion formula for l=0 and higher values, compound nucleus, Direct reactions, Transfer reactions. *(Lectures 7)*

Text Books:

1. Nuclear Physics: *Irving Kaplan (Narosa), 2001.*
2. Theory of Nuclear Structure: *R.R. Roy and B.P. Nigam (New Age, New Delhi) 2005.*
3. Handbook of Nuclear Physics: *S.N. Ghoshal, S. Chand Publishing* (1994).

Reference Books:

1. Basic Ideas and Concepts in Nuclear Physics: *K. Hyde (Institute of Physics) 2004.*
2. Nuclear physics: Experimental and Theoretical, *H.S. Hans (New Academic Science) 2nd ed (2011).*

MSPH-533-21	**Particle Physics**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: course on Quantum Mechanics and Quantum field Theory			
The aim and objective of the course on **Particle Physics** is to introduce the M.Sc. students to the invariance principles and conservation laws, hadron-hadron interactions, relativistic kinematics, static quark model of hadrons and weak interactions so that they grasp the basics of fundamental particles in proper perspective.			
Course Outcomes: At the end of the course, the student will be able to			

CO1	Overview the particle spectrum, their interaction and major historical and latest developments.
CO2	Understand the implications of various invariance principles and symmetry properties in particle physics.
CO3	Master relativistic kinematics for computations of outcome of various reactions and decay processes.
CO4	Properties of baryons and mesons in terms of naive nonrelativistic quark model.
CO5	Weak interaction in quarks and leptons and how that this is responsible for β decay.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	2	2	1	1	2	1	2	1	3
CO2	1	1	1	2	2	1	1	2	2	2	2	3
CO3	1	1	1	2	2	1	1	2	2	2	-	1
CO4	1	1	1	2	2	1	2	2	2	2	2	2
CO5	1	1	1	2	2	1	2	1	3	2	-	2

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Detailed Syllabus:

1. **Introduction:** Fermions and bosons, particles and antiparticles, quarks and leptons, interactions and fields in particle physics, classical and quantum pictures, Yukawa picture, types of interactions - electromagnetic, weak, strong and gravitational, units. *(Lectures 7)*
2. **Invariance Principles and Conservation Laws:** Invariance in classical mechanics and quantum mechanics, Parity, Pion parity, Charge conjugation, Positronium decay, Time reversal invariance, CPT theorem. *(Lectures 7)*
3. **Hadron-Hadron Interactions:** Cross section and decay rates, Pion spin, Isospin, Two nucleon system, Pion-nucleon system, Strangeness and Isospin, G-parity, Total and Elastic cross section, Particle production at high energy. *(Lectures 7)*
4. **Relativistic Kinematics and Phase Space:** Introduction to relativistic kinematics, particle reactions, Lorentz invariant phase space, two-body and three-body phase space, dalitz plots, K-2p-decay, t-θ puzzle, dalitz plots for dissimilar particles, Breit-Wigner resonance formula, Mandelstem variables. *(Lectures 7)*
5. **Static Quark Model of Hadrons:** The Baryon decuplet, quark spin and color, baryon octet, quark-antiquark combination. *(Lectures 7)*
6. **Weak Interactions:** Classification of weak interactions, Fermi theory, Parity non conservation in ß-decay, experimental determination of parity violation, helicity of neutrino, K-decay, CP violation in K- decay and its experimental determination. *(Lectures 7)*

Text Books:

1. Introduction to High Energy Physics: D.H. Perkins (Cambridge University Press), 2000.
2. Introduction to Quarks and Partons: F.E. Close (Academic Press, London), 1979.
3. Introduction to Particle Physics: M.P. Khanna (Prentice Hall of India, New Delhi), 2004.

Reference Books:

1. An Introductory Course of Particle Physics: Palash Pal (CRC Press).
2. Elementary Particles: I.S. Hughes (Cambridge University Press), 3rd ed. 1991.
3. Gauge Theory of Elementary Particle Physics: T.P Cheng & L.F. Li (Oxford).
4. Dynamics of the Standard Model: J.F. Donoghue (Cambridge University Press).
5. First Book of Quantum Field Theory: A. Lahiri & P. Pal, Narosa, New Delhi.
6. Introduction to Quantum Field Theory: M. Peskin & D.V. Schroeder. (Levant Books).

Elective Subject -I

MSPH-534-21	Fibre Optics and Non-linear optics	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of graduate level optics and Lasers

Course Objectives: Course Objectives: The aim and objective of the course on **Fibre Optics and Nonlinear Optics** is to expose the M.Sc. students to the basics of the challenging research field of optical fibres and their use in nonlinear optics.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the structure of optical fiber and describe properties of optical fibers.
CO2	Identify and compare the various processes of fibers fabrication
CO3	Describe the optics of anisotropic media
CO4	Analyze the electro-optic and acousto-optic effects in fibers
CO5	analyze non-linear effects in optical fibers.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	-	1	-	1	-	1	-	3	-	1
CO2	3	2	1	1	1	1	-	1	-	3	-	1
CO3	2	2	-	1	-	1	-	1	-	3	-	1
CO4	3	2	1	1	1	-	-	1	-	3	-	1
CO5	3	2	1	1	1	-	-	1	-	3	-	1

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Detailed Syllabus:

1. **Optical fibre and its properties:** Introduction, basic fibre construction, propagation of light, modes and the fibre, refractive index profile, types of fibre, dispersion, data rate and band width, attenuation, leaky modes, bending losses, cut-off wavelength, mode field diameter, other fibre types. *(Lectures 7)*

2. **Fiber fabrication and cable design:** Fibre fabrication, mass production of fiber, comparison of the processes, fiber drawing process, coatings, cable design requirements, typical cable design, testing. *(Lectures 5)*

3. **Optics of anisotropic media:** Introduction, the dielectric tensor, stored electromagnetic energy in anisotropic media, propagation of monochromatic plane waves in anisotropic media, directions of D for a given wave vector, angular relationships between D, E, H, k and Poynting vector S, the indicatrix, uniaxial crystals, index surfaces, other surfaces related to the uniaxial indicatrix, Huygenian constructions, retardation, biaxial crystals, intensity through polarizer/waveplate/ polarizer combinations. *(Lectures 10)*

4. **Electro-optic and acousto-optic effects and modulation of light beams**: Introduction to the electro-optic effects, linear electro-optic effect, quadratic electro-optic effects, longitudinal electro-optic modulation, transverse electro optic modulation, electro optic amplitude modulation, electro-optic phase modulation, high frequency wave guide, electro-optic modulator, strain optic tensor, calculation of LM for a logitudinal acoustic wave in isotropic medium, Raman-Nath diffraction, Raman-Nath acousto-optic modulator. *(Lectures 10)*

5. **Non-linear optics/processes**: Introduction, anharmonic potentials and nonlinear polarization, non-linear susceptibilities and mixing coefficients, parametric and other nonlinear processes, macroscopic and microscopic susceptibilities. *(Lectures 8)*

Text Books:

1. The Elements of Fibre Optics: *S.L.Wymer and Meardon (Regents/Prentice Hall), 1992.*

Reference Books:

1. Lasers and Electro-Optics: *C.C. Davis (Cambridge University Press), 1996.*
2. Optical Electronics: *Gathak & Thyagarajan (Cambridge Univ. Press), 1989.*
3. The Elements of Non-linear Optics: *P.N. Butcher & D. Cotter (Cambridge University Press), 1991.*

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Elective Subject -I

MSPH-535-21	Radiation Physics	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of graduate level nuclear physics

Course Objectives: The aim and objective of the course on **Radiation Physics** is to expose the students of M.Sc. class to the relatively advanced topics Radiation Physics and nuclear reactions so that they understand the details of the underlying aspects and can use the techniques if they decide to be radiation or nuclear physicists in their career.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand various modes of interaction of electromagnetic radiations and charged particles with matter.
CO2	Distinguish various types of radiations based on their interaction with matter.
CO3	Learn and understand about different detectors.
CO4	Use different analytical technique such as XRF, PIXE, neutron activation analysis and electron spin resonance spectroscopy.
CO5	Design experiments to analyze effects of radiation on various objects.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	-	1	1	1	1	1	2	1	2
CO2	1	1	1	-	1	2	2	1	2	2	2	2
CO3	2	1	2	2	2	2	2	2	2	2	2	2
CO4	2	2	2	2	2	3	3	2	2	2	2	2
CO5	3	2	2	3	3	3	3	2	2	2	2	2

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Detailed Syllabus:

1. **Interaction of electromagnetic radiations with Matter:** Different photon interaction processes viz. photoelectric effect, Compton scattering and pair production. Minor interaction processes, Energy and Z dependence of partial photon interaction processes. Attenuation coefficients, Broad and narrow beam geometries. Multiple scattering.
(Lectures 10)

2. **Interaction of charged particles with Matter:** Elastic and inelastic collisions with electrons and atomic nucleus. Energy loss of heavy charged particles. Range-energy relationships, Straggling. Radiative collisions of electrons with atomic nucleus.
(Lectures 10)

3. **Nuclear Detectors and Instrumentation:** General characteristics of detectors, Gas filled detectors, Organic and inorganic scintillation detectors, Semi-conductor detectors [Si(Li), Ge(Li) HPGe]. Room temperature detectors, Gamma ray spectrometers. Gamma ray spectrometry with NaI(Tl) scintillation and semiconductor detectors.
(Lectures 10)

4. **Analytical Techniques:** Principle, instrumentation and spectrum analysis of XRF, PIXE and neutron activation analysis (NAA) techniques. Theory, instrumentation and applications of electron spin resonance spectroscopy (ESR). Experimental techniques and applications of Rutherford backscattering. Applications of elemental analysis and nuclear medicine.
(Lectures 10)

Text Books:

1. The Atomic Nucleus: R.D. Evans, Tata Mc Graw Hill, New Delhi.
2. Nuclear Radiation Detectors: S. S. Kapoor and V. S. Ramamurthy, New Age, International, New Delhi.

Reference Books:

1. Radiation Detection and Measurements: G. F. Knoll, Wiley & Sons, New Delhi.
2. Introductory Nuclear Physics: K. S. Krane, Wiley & Sons, New Delhi.
3. An Introduction to X-ray Spectrometry: Ron Jenkin, Wiley.
4. Techniques for Nuclear and Particle Physics Experiments: W. R. Leo, Narosa Publishing House, New Delhi.
5. Introduction to experimental Nuclear Physics: R.M. Singru, Wiley & Sons, New Delhi

Elective Subject -I

MSPH-536-21	Nonlinear Dynamics	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of graduate level physics

Course Objectives: The aim and objective of the course on **Nonlinear Dynamics** is to familiarize the M.Sc. students with the basics of the recently emerging research field of dynamics of nonlinear Hamiltonian systems.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand basic knowledge of nonlinear dynamics and phenomenology of chaos.
CO2	Apply the tools of dynamical systems theory in context to models.
CO3	Learn skills by solving problems on solving nonlinear problems using numerical methods.
CO4	Understand Hamilton approach for describing various physical system.
CO5	Quantify classical chaos and Quantum chaos.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	1	-	1	2	1	2	2	2	2
CO2	2	2	1	2	1	1	1	1	1	2	1	1
CO3	3	2	-	2	1	1	2	1	1	2	1	1
CO4	2	2	-	2	1	1	2	1	1	2	1	1
CO5	2	2	-	2	1	1	2	1	1	2	1	1

Detailed Syllabus:

1. **Phenomenology of Chaos**: Linear and nonlinear systems, A nonlinear electrical system, Biological population growth model, Lorenz model; determinism, unpredictability and divergence of trajectories, Feigenbaum numbers and size scaling, self similarity, models and universality of chaos. *(Lectures 8)*

2. **Dynamics in State Space:** State space, autonomous and nonautonomous systems, dissipative systems, one dimensional state space, Linearization near fixed points, two dimensional state space, dissipation and divergence theorem. Limit cycles and their stability, Bifurcation theory, Heuristics, Routes to chaos. Three-dimensional dynamical systems, fixed points and limit cycles in three dimensions, Lyapunov exponents and chaos. Three dimensional iterated maps, U-sequence. *(Lectures 10)*

3. **Hamiltonian System**: Non-integrable systems, KAM theorem and period doubling, standard map. Applications of Hamiltonian Dynamics, chaos and stochasticity. *(Lectures 8)*

4. **Quantifying Chaos**: Time series, Lyapunov exponents. Invariant measure, Kolmogorov - Sinai entropy. Fractal dimension, Statistical mechanics and thermodynamic formalism. *(Lectures 7)*

5. **Quantum Chaos**: Quantum Mechanical analogies of chaotic behaviour, Distribution of energy eigenvalue spacing, chaos and semi-classical approach to quantum mechanics. *(Lectures 7)*

Text Books:

1. Chaos and Non Linear Dynamics: R.C. Hilborn (Oxford Univ. Press), 2001.

Reference Books:

1. Chaos in Dynamical Systems: E. Ott (Cambridge Univ. Press), 2001.
2. Applied Nonlinear Dynamics: A.H. Nayfeh and B. Balachandran (Wiley), 1995.
3. Chaos in Classical and Quantum Mechanics: M.C. Gutzwiller (Springer-Verlag), 1990.

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Elective Subject -II

MSPH-537-21	Plasma Physics	L-3, T-1, P-0	4 Credits
Pre-requisite: Course on Electrodynamics			
Course Objectives: The aim and objective of the course on **Plasma Physics** is to expose the M.Sc. students to the basics of the challenging research field Plasma physics.			
Course Outcomes: At the end of the course, the student will be able to			

CO1	Understand the origin of plasma, conditions of plasma formation and properties of plasma.
CO2	Distinguish between the single particle approach, fluid approach and kinetic statistical approach to describe different plasma phenomena.
CO3	Classify propagation of electrostatic and electromagnetic waves in magnetized and non-magnetized plasmas
CO4	Describe the basic transport phenomena such as plasma resistivity, diffusion and mobility for both magnetized and non-magnetized plasmas.
CO5	Formulate the conditions for describing a plasma to be in a state of thermodynamic equilibrium, or non-equilibrium, and analyze the stability of this equilibrium.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	-	1	1	1	1	2	2	1	2
CO2	1	1	1	-	1	1	1	1	2	2	1	2
CO3	1	1	1	-	1	1	1	1	2	2	1	2
CO4	1	1	1	-	1	1	1	1	2	2	1	2
CO5	1	3	2	2	2	2	1	1	2	2	1	2

Detailed Syllabus:

1. **Introduction:** Plasma State, elementary concepts and definitions of temperature and other parameters, occurrence and importance of plasma for various applications, Production of Plasma in the laboratory, Physics of glow discharge, electron emission, ionization, breakdown of gases, Paschen's laws and different regimes of E/p in a discharge, Townsend discharge and the evolution of discharge. *(Lectures 8)*

2. **Plasma diagnostics:** Probes, energy analyzers, magnetic probes and optical diagnostics, preliminary concepts. *(Lectures 5)*

3. **Single particle orbit theory:** Drifts of charged particles under the effect of different combinations of electric and magnetic fields, Crossed electric and magnetic fields, Homogenous electric and magnetic fields, spatially varying electric and magnetic fields, time varying electric and magnetic fields, particle motion in large amplitude waves. *(Lectures 8)*

4. **Fluid description of plasmas:** distribution functions and Liouville's equation, macroscopic parameters of plasma, two and one fluid equations for plasma, MHD approximations commonly used in one fluid equations and simplified one fluid and MHD equations. dielectric constant of field free plasma, plasma oscillations, space charge waves of warm plasma, dielectric constant of a cold magnetized plasma, ion- acoustic waves, Alfven waves, Magnetosonic waves. *(Lectures 10)*

5. **Stability of fluid plasma:** The equilibrium of plasma, plasma instabilities, stability analysis, two stream instability, instability of Alfven waves, plasma supported against gravity by magnetic field, energy principle. microscopic equations for my body system: Statistical equations for many body systems, Vlasov equation and its properties, drift kinetic equation and its properties. *(Lectures 7)*

Text Books:

1. Introduction to Plasma Physics, *F.F. Chen*

Reference Books:

1. Principles of Plasma Physics, *Krall and Trievelpice*
2. Introduction to Plasma Theory, *D.R. Nicholson*
3. The Plasma State, *J.L. Shohet*
4. Introduction to Plasma Physics, *M. Uman*
5. Principles of Plasma Diagnostic, *I.H. Hutchinson*

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Elective Subject-II

MSPH-538-21	Structures, Spectra and Properties of Biomolecules	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of graduate level chemistry and physics

Course Objectives: The aim and objective of the course on **Structures, Spectra and properties of Biomolecules** is to familiarize the M.Sc. students with the basics of the recently emerging research field of dynamics of Structures, Spectra and properties of Biomolecules.

Course Outcomes: At the end of the course, the student will be able to

CO1	Describe various structural and chemical bonding aspects of Biomolecules.
CO2	Understand structure and theoretical techniques and their application to Biomolecules.
CO3	Understand use of various spectroscopic techniques and their application to the Biomolecules.
CO4	Understand the structure-Function relationship and modeling of biomolecules.
CO5	Outline and correlate for providing solution to interdisciplinary problem.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	2	2	1	2	1	2	2	1	2
CO2	2	2	1	2	2	2	2	-	2	2	1	2
CO3	2	2	1	2	1	2	2	-	2	2	1	2
CO4	2	2	1	2	2	2	2	-	2	2	1	2
CO5	2	2	1	2	2	1	2	1	2	2	1	2

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Detailed Syllabus:

1. **Structure Aspects of Biomolecule:** Conformational Principles, Conformation and Configuration Isomers and Derivatives, Structure of Polynucleotides, Structure of Polypeptides, Primary, Secondary, Tertiary and Quaternary Structure of Proteins, Structure of Polysaccharides. *(Lectures10)*

2. **Theoretical Techniques and Their Application to Biomolecules:** Hard Sphere Approximation, Ramachandran Plot, Potential Energy Surface, Outline of Molecular Mechanics Method, Brief ideas about Semi-empirical and Ab initio Quantum Theoretical Methods, Molecular Charge Distribution, Molecular Electrostatic Potential and Field and their uses. *(Lectures 10)*

3. **Spectroscopic Techniques and their Application to Biomolecules:** Use of NMR in Elucidation of Molecular Structure, Absorption and Fluorescence Spectroscopy, Circular Dichroism, Laser Raman Spectroscopy, IR spectroscopy, Photoacoustic Spectroscopy, Photo-biological Aspects of Nucleic Acids. *(Lectures 10)*

4. **Structure-Function Relationship and Modeling:** Molecular Recognition, Hydrogen Bonding, Lipophilic Pockets on Receptors, Drugs and Their Principles of Action, Lock and Key Model and Induced fit Model. *(Lectures 10)*

Text Books:

1. *Srinivasan & Pattabhi:* Structure Aspects of Biomolecules.

Reference Books:

1. *Govil & Hosur*: Conformations of Biological Molecules
2. *Price:* Basic Molecular Biology
3. *Pullman:* Quantum Mechanics of Molecular Conformations
4. *Lehninger:* Biochemistry
5. Mehler & Cordes: Biological Chemistry
6. *Smith and Hanawait:* molecular Photobiology, Inactivation and Recovery

Elective Subject - II

MSPH-539-21	Science of Renewable source of Energy	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of graduate level semiconductor physics

Course Objectives: The aim and objective of the course on **Science of renewable Energy Sources** is to expose the M.Sc. students to the basics of the alternative energy sources like solar energy, hydrogen energy, etc.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the energy demand of world & distinguish between traditional and alternative form of energy.
CO2	Describe the concept of solar energy radiation and thermal applications.
CO3	Analyze making of solar cell and its types.
CO4	Identify hydrogen as energy source, its storage and transportation methods.
CO5	Compare wind energy, wave energy and ocean thermal energy conversion.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	1	-	1	2	1	2	3	2	2
CO2	2	2	1	2	1	1	1	1	1	3	1	1
CO3	3	2	-	2	1	1	2	1	1	3	1	1
CO4	2	2	-	2	1	1	2	1	1	3	1	1
CO5	2	2	-	2	1	1	2	1	1	3	1	1

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Detailed Syllabus:

1. **Introduction**: Production and reserves of energy sources in the world and in India, need for alternatives, renewable energy sources. *(Lectures 8)*

2. **Solar Energy**: Thermal applications, solar radiation outside the earth's atmosphere and at the earth's surface, Principal of working of solar cell, Performance characteristics of solar cell. Types of solar cell, crystalline silicon solar cell, Thin film solar cell, multijunction solar cell, Elementary ideas of perovskite solar cell, dye synthesized solar cell and Tandem solar cell, PV solar cell, module array, and panel, Applications. *(Lectures 11)*

3. **Hydrogen Energy**: Environmental considerations, solar hydrogen through photo electrolysis and photocatalytic process, physics of material characteristics for production of solar hydrogen. Storage processes, solid state hydrogen storage materials, structural and electronic properties of storage materials, new storage modes, safety factors, use of hydrogen as fuel; use in vehicles and electric generation, fuel cells. *(Lectures 10)*

4. **Other sources**: Nature of wind, classification and descriptions of wind machines, power coefficient, energy in the wind, wave energy, ocean thermal energy conversion (OTEC), system designs for OTEC, basic idea about biogas, biofuel, and biodiesel. *(Lectures 8)*

Text Books:

1. Solar Energy: *S.P. Sukhatme (Tata McGraw-Hill, New Delhi), 2008.*

Reference Books:

1. Solar Cell Devices: *Fonash (Academic Press, New York),2010.*
2. Fundamentals of Solar Cells, Photovoltaic Solar Energy: *Fahrenbruch and Bube (Springer, Berlin), 1982.*
3. Photoelectrochemical Solar Cells: *Chandra (New Age, New Delhi).*

MSPH-540-21	Condensed Matter Physics Lab	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of graduate level solid state physics experiments

Course Objectives: The aim and objective of the courses on **Condensed Matter Physics Lab** is to train the students of M.Sc. class to advanced experimental techniques in condensed matter physics so that they can investigate various relevant aspects and are confident to handle sophisticated equipment and analyze the data.

Course Outcomes: At the end of the course, the student will be able to

CO1	Measure conductivity, resistivity and thermo-dynamical properties of solids.
CO2	Measure magnetic properties and magnetic behavior of magnetic materials.
CO3	Describe the lattice dynamics of simple lattice structures in terms of dispersion relations.
CO4	Design and carry out scientific experiments as well as accurately record and analyze the results of experiments.
CO5	Solve problem with critical thinking and analytical reasoning.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	1	1	-	-	2	2	2	2	2
CO2	2	1	1	1	1	-	-	2	2	2	2	2
CO3	1	1	1	1	1	-	-	2	2	2	2	2
CO4	2	2	2	2	2	2	2	2	2	2	2	2
CO5	3	3	2	2	3	2	2	2	2	2	2	2

Detailed Syllabus:

Note: Students are expected to perform atleast ten experiments out of following list.

1. To study temperature dependence of conductivity of a given semiconductor crystal using four probe method.
2. Verification of curie-weiss law for the electrical susceptibility of a ferroelectric material.
3. To determine charge carrier density and Hall coefficient by Hall effect.
4. To determine magnetic susceptibility of material using Quink 's tube method.
5. To determine energy gap and resistivity of the semiconductor using four probe method.
6. To study the B-H loop characteristics.
7. To determine dielectric constant of a material with Microwave set up.
8. To measure the Curie temperature of a given PZT sample.
9. To measure the velocity of ultrasonic wave in liquids.
10. To study dispersion relation for Mono-atomic and Diatomic lattices using Lattice dynamic kit.
11. To study the properties of crystals using X-Ray Apparatus.

Text Books:

1. Introduction to Solid State Physics: *C. Kittel (Wiley, New York), 8th ed. 2005.*
2. Quantum Theory of Solids: *C. Kittel (Wiley, New York) 1987.*

Reference Books:

1. Principles of the Theory of Solids: *J. Ziman (Cambridge University Press) 1971*
2. Solid State Theory: *Walter A. Harrison (Tata McGraw-Hill, New Delhi) 1970.*
3. Liquid Crystals: *S. Chandrasekhar (Cambridge University), 2nd ed. 1991.*

Elective Subject -III

MSPH-541-21	Physics of Nanomaterials	L-3, T-1, P-0	4 Credits

Pre-requisite: Condensed matter physics

Course Objectives: The aim and objective of the course on **Physics of Nano-materials** is to familiarize the students of M.Sc. to the various aspects related to preparation, characterization and study of different properties of nanomaterials so that they can pursue this emerging research field as career.

Course Outcomes: At the end of the course, the student will be able to

CO1	Apply the knowledge on free electron theory to the band structure of metals, insulators, and semiconductors.
CO2	Acquire knowledge of basic approaches to synthesize the inorganic nanoparticles
CO3	Describe the use of unique optical properties of nanoscale metallic structures for analytical and biological applications
CO4	Understand the physical and chemical properties of carbon nanotubes and nanostructured mesoporous materials.
CO5	Determine the structure-property relationships in nanomaterials as well as the concepts, not applicable at larger length scales.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	2	2	-	1	2	1	1	2	2	3
CO2	1	2	2	2	-	2	2	1	1	2	2	3
CO3	1	2	2	2	-	2	2	1	1	2	2	3
CO4	1	2	2	2	-	2	2	1	1	2	2	3
CO5	1	2	2	2	-	2	2	1	1	2	2	3

Detailed Syllabus:

1. **Introductory Aspects:** Free electron theory and its features, Idea of band structure - metals, insulators and semiconductors. Density of state in one, two, and three dimensional bands and its variation with energy, Effect of crystal size on density of states and band gap. Examples of nanomaterials. *(Lectures 8)*

2. **Synthesis of Nanomaterials:** Bottom up: Cluster beam evaporation, ion beam deposition, chemical bath deposition with capping techniques and Top down: Ball Milling. *(Lectures 8)*

3. **General Characterization Techniques:** Determination of particle size, study of texture and microstructure, Increase in x-ray diffraction peaks of nanoparticles, shift in photo luminescence peaks, variation in Raman spectra of nanomaterials, photoemission microscopy, scanning force microscopy. *(Lectures 8)*

4. **Quantum Dots:** Electron confinement in infinitely deep square well, confinement in one and two-dimensional wells, idea of quantum well structure, Examples of quantum dots, spectroscopy of quantum dots. *(Lectures 8)*

5. **Carbon based Nanomaterials:** Synthesis, structural, and electronics properties of fullerenes, carbon nanotubes, and graphene, Functionalisation of carbon Nanomaterials, Applications of carbon based Nanomaterials. *(Lectures 8)*

Text Books:

1. Nanotechnology-Molecularly Designed Materials: *G.M. Chow & K.E. Gonsalves (American Chemical Society), 1996.*
2. Nanotechnology Molecular Speculations on Global Abundance: *B.C. Crandall (MIT Press), 1996.*

Reference Books:

1. Quantum Dot Heterostructures: *D. Bimerg, M. Grundmann and N.N. Ledentsov (Wiley),1998.*
2. Introduction to Nanotechnology, Charles P. Poole Jr., Frank J. Owens, Wiley Student edition, John Wiley & Sons Inc. Publishes (2003).
3. Nanotechnology: A gentle introduction to the next Big Idea, Mark Ratner & Daniel Ratner, LPE, Pearson Education (2002).
4. Nanostructures and Nanomaterials: Synthesis: *Properties and Applications, G. Cao, Imperial College Press 2nd edition (2011).*
5. NANO: The Essentials "Understanding Nanoscience and Nanotechnology": *T. Pradeep, Tata McGraw-Hill Publishing Company Limited, New Delhi (2007).*
6. Advanced Micro- & Nanosystems, CMOS-MEMS: *O. Brand and G K. Fedder, Wiley-VCH (2008)*
7. Nanophotonics: *Paras N. Prasad, Wiley- Interscience (2004).*
8. Biomedical Nanotechnology: *NH Malsch, Taylor & Francis Group (2005).*

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Elective Subject -III

MSPH-542-21	**Experimental Techniques in Nuclear and Particle Physics**	**L-3, T-1, P-0**	**4 Credits**

Pre-requisite: Course on Nuclear and Particle Physics

Course Objectives: The aim and objective of the course on **Experimental Techniques in Nuclear and Particle Physics** is to expose the students of M.Sc. students to experimental aspects of different equipment and methods used in the fields of nuclear physics and particle physics.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand various experimental techniques for describing interaction of radiations with matter.
CO2	Use error analysis for experimental data.
CO3	Knowledge about the different types of the radiation detectors.
CO4	Apply the knowledge of detectors for various applications
CO5	Equipped with the basic knowledge about the experimental methods used in the various laboratories across the world.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	2	-	1	-	-	1	-	1	1	1
CO2	-	-	-	3	-	-	-	3	1	1	1	1
CO3	-	-	1	2	3	-	1	3	2	2	2	2
CO4	-	-	1	3	3	1	1	2	2	2	2	2
CO5	-	-	1	3	1	1	1	2	2	2	2	2

Detailed Syllabus:

1. **Detection of radiations:** Interaction of gamma-rays, electrons, heavy charged particles, neutrons, neutrinos and other particles with matter (Qualitative description only) . General properties of Radiation detectors, energy resolution, detection efficiency and dead time, Error propagation in experimental data. *(Lectures 8)*

2. **Detectors:** Introduction to Gas-filled detectors, Proportional counters, space charge effects, energy resolution, time characteristics of signal pulse, position-sensitive proportional counters, Multiwire proportional chambers, Drift chamber. Organic and inorganic scintillators and their characteristics, light collection and coupling to photomultiplier tubes, Semiconductor detectors, Ge and Si(Li) detectors, Charge production and collection processes, Pulse height spectrum. *(Lectures 16)*

3. **Applications of Detectors:** Description of electron and gamma ray spectrum from detector, semiconductor detectors in X- and gamma-ray spectroscopy, Semiconductor detectors for charged particle spectroscopy and particle identification. *(Lectures 8)*

4. **Experimental methods:** Large gamma and charge particle detector arrays, heavy-ion reaction analysers, production of radioactive ion beams. Detector systems for high energy experiments: Collider physics (brief account), Particle Accelerators (brief account), Modern Hybrid experiments- CMS. *(Lectures 8)*

Text Books:

1. Techniques in Nuclear and particle Experiments by W.R. Leo (Springer), 1994.

Reference Books:

1. Radiation detection and measurement by Glenn F. Knoll (Wiley), 2010.
2. Introduction to Experimental Particle Physics by Richard Fernow (Cambridge University Press), 2001.
3. Detectors for particle radiation by Konrad Kleinknecht (Cambridge University Press), 1999.

Elective Subject -III

MSPH-543-21	Superconductivity and Low Temperature Physics	L-3, T-1, P-0	4 Credits

Pre-requisite: course in Condensed Matter Physics

Course Objectives: The objective of the course on Superconductivity and Low Temperature Physics is to build fundamental as well as advanced understanding in the field of superconductivity. Students will not only learn theoretical aspects but also acquainted with latest trends in the experimental techniques as well. Low temperature is one of the most versatile and important tool to explore rich physics of superconductivity. With latest technology the lowest achievable temperature now is close to few µK. Students will also be introduced to the theoretical background of low temperature techniques as well as the high-Tc superconductors.

Course Outcomes: At the end of the course, the student will be able to

CO1	Theoretical understanding of the concept of superconductivity.
CO2	Correlate observed experimental properties of superconductors with origin of superconductivity.
CO3	Describe appropriate theoretical model for describing behavior of superconductors.
CO4	Provide exposure to High Tc class of superconductors and theoretical understanding of low temperature techniques.
CO5	Provide exposure about the experimental techniques for measurement of superconductivity.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	2	2	2	2	2	1	2	2	1	2
CO3	1	2	2	2	2	2	2	1	2	2	-	2
CO3	1	2	2	2	2	2	2	-	2	2	3	2
CO4	1	2	2	2	2	2	2	-	2	2	2	2
CO5	1	2	2	2	2	2	2	1	2	1	3	2

Detailed Syllabus:

1. **Superconductivity:** Introduction, Thermodynamics, The London Equations, penetration depth, Superconductors in magnetic field, Ginzberg-Landau Theory, Type I and II superconductors, BCS theory, second quantization, Cooper Pairing, energy gap Tunnelling, Josephson effects and SIS tunneling. *(Lectures 10)*

2. **Preparation and measurement techniques:** Single crystal growth: Optical image furnace, seeded melt growth, Thin film deposition: Pulsed laser deposition, sputtering, Resistivity measurements, magnetic measurements, Point contact spectroscopy, scanning tunneling microscopy and spectroscopy. *(Lectures 10)*

3. **Cryogenics:** Thermal and electrical properties of different materials at low temperatures, Cooling methods above 1K, Joule-ThomPOn, Gifford-McMohan, Evaporation cooling, Liquefication of Helium, Cooling methods below 1K, dilution refrigeration, adiabatic demagnetisation. *(Lectures 10)*

4. **Introduction to high-Tc superconductors:** Discovery of high-Tc superconductors, Mechanisms of superconductivity in high-Tc superconductors, Introduction to high-Tc superconducting compound like YBCO, Synthesis, Structure and properties, Electronics and applications. *(Lectures 10)*

Text Books:

1. Introduction to superconductivity: Michael Tinkham, Courier Corporation, 2004.

Reference Books:

1. Introduction to superconductivity: *A.C. Rose-Innes and E.H. Rhoderick,* Pergamon Press, 2004.
2. Experimental techniques in low temperature physics: *G.K. White and P.J. Meeson,* Oxford Univ. Press, 2001.
3. Experimental low temperature physics: *A. Kent,* MacMillan Press, 1992.
4. The theory of superconductivity in high-TC Cuprates: *P.W. Anderson,* Princeton Series Publications.

Elective Subject -IV

MSPH-544-21	Advanced Condensed Matter Physics	L-3, T-1, P-0	4 Credits

Pre-requisite: course on Condensed Matter Physics

Course Objectives: The objective of the course on **Advanced Condensed Matter Physics** is to familiarize the M.Sc. students with relatively advanced topics like optical properties, magnetism, superconductivity, magnetic resonance techniques and disordered solids so that they are confident to use the relevant techniques in their later career.

Course Outcomes: At the end of the course, the student will be able to

CO1	Comprehend and describe the Optical properties of solids employing macroscopic theories.
CO2	Explain various types of magnetic phenomenon in solids, underlying physics, and correlation with the applications.
CO3	Understand and realize the use of NMR methods for describing solids.
CO4	Interpret the phenomena, behavior and applications of superconductors.
CO5	Figure out and perceive the effect of deformation and disorder on the behavior of solids

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	2	2	2	1	1	2	2	2	3
CO2	2	2	2	2	1	2	1	2	2	1	2	3
CO3	3	2	2	2	2	1	2	2	2	2	1	2
CO4	2	2	2	2	2	2	2	1	2	2	2	2
CO5	3	2	2	2	1	2	2	2	2	1	2	3

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Detailed Syllabus:

1. **Optical Properties:** Macroscopic theory; Reflectance and Transmittance of a slab; generalized susceptibility, Kramers- Kronig relations, Brillouin scattering, Raman effect in crystals; interband transitions. (Lectures 8)

2. **Magnetism:** Dia and para-magnetism in materials; Langevin theory of diamagnetism, quantum theory of diamagnetism and paramagnetism. Exchange interaction. Heisenberg Hamiltonian; Hubbard model; mean field theory; Ferro-, ferri- and antiferromagnetism; Magnons: spin waves, thermal excitation of magnons; Bloch T2/1 law. (Lectures 8)

3. **Nuclear Magnetic Resonance in Solids:** Origin of NMR in solids– equations of motion, line width, motional narrowing, Knight shift. (Lectures 8)

4. **Superconductivity:** Experimental Survey; Basic phenomenology; Vortex state of a Type II superconductors; BCS pairing mechanism and nature of BCS ground state; Flux quantization; Tunneling Experiments; High Tc superconductors; Ginzburg-Landau theory; Greens functions at zero temperature; Applications of Greens functions to superconductivity. (Lectures 8)

5. **Disordered Solids:** Basic concepts in point defects and dislocations; Noncrystalline solids: diffraction pattern, Glasses, Amorphous semiconductors and Ferromagnets, Heat capacity and Thermal conductivity of amorphous solids; Quasicrystals. (Lectures 8)

Text Books:

1. Introduction to Solid State Physics: C. Kittel (Wiley, New York) 2005.
2. Quantum Theory of Solids: C. Kittel (Wiley, New York) 1987.

Reference Books:

1. Principles of the Theory of Solids: *J. Ziman (Cambridge University Press) 1971.*
2. Solid State Physics: *H. Ibach and H. Luth (Springer, Berlin), 3rd. ed. 2001.*
3. A Quantum Approach to Solids: *P.L. Taylor (Prentice-Hall, Englewood Cliffs), 1970.*
4. Intermediate Quantum Theory of Solids: *A.O.E. Animalu (East-West Press, New Delhi), 1991.*
5. Solid State Physics : *Ashcroft and Mermin (Reinhert& Winston, Berlin), 1976.*

Elective Subject -IV

MSPH-545-21	**Advanced Particle Physics**	**L-3, T-1, P-0**	**4 Credits**

Pre-requisite: course on particle physics

Course Objectives: The objective of the course on **Advanced Particle Physics** is to expose the students of M.Sc. class to the relatively advanced topics related to symmetry breaking in quantum field theory, standard model of particle physics, QCD and quark model, and various unification schemes so that they understand these aspects properly and are well equipped to pursue a career in high energy physics.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand various global and local gauge symmetries of system, invariance of action, symmetry breaking, and Higgs mechanism.
CO2	Need for standard model of particle physics and its limitations and the properties of QCD.
CO3	Define the problem of divergencies in quantum field theories and the renormalisation methods.
CO4	Asymptotic freedom and infrared slavery of the running coupling constant in non-abelian gauge theory of strong interactions -QCD.
CO5	Given exposure about the physics beyond the Standard Model.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	2	2	-	2	2	2	2
CO2	2	1	1	2	2	2	2	-	2	2	2	2
CO3	1	2	1	2	2	2	2	-	2	2	1	2
CO4	1	1	2	1	2	2	2	-	1	2	1	2
CO5	1	2	2	1	2	2	2	-	2	2	3	2

Detailed Syllabus:

1. **Symmetries and Symmetry Breaking in QFT:** Continuous groups: Lorentz group SO(1,2) and its representations, Unitary groups and Orthogonal groups and their representations, Discrete symmetries: Parity, Charge Conjugation and Time reversal Invariance, CP, CPT. (Lectures 10)

2. **Global and Local invariances of the Action:** Approximate symmetries, Noethers theorem, Spontaneous breaking of symmetry and Goldstone theorem, Higgs mechanism, Abelian and Non-Abelian gauge fields, Lagrangian and gauge invariant coupling to matter fields. (Lectures 10)

3. **Standard Model of Particle Physics:** SU(2) x SU(1) x U(1) gauge theory, Coupling to Higgs and Matter fields of 2 generations, Gauge boson and fermion mass generation via spontaneous symmetry breaking, CKM matrix, Low energy Electroweak effective theory, Elementary electroweak scattering processes. (Lectures 10)

4. **QCD and quark model:** Asymptotic freedom and Infrared slavery, confinement hypothesis, Approximate flavor symmetries of the QCD lagrangian, Classification of hadrons by flavor symmetry: SU(1) and SU(2) multiplets of Mesons and Baryons, Chiral symmetry and chiral symmetry breaking, Sigma model, Parton model and Deep inelastic scattering structure functions. (Lectures 10)

Text Books:

1. Gauge Theory of Elementary Particle Physics: T.P Cheng & L.F. Li (Oxford).
2. An Introductory Course of Particle Physics: Palash Pal (CRC Press).

Reference Books:

1. First Book of Quantum Field Theory: A. Lahiri & P. Pal, Narosa, New Delhi.
2. Introduction to Quantum Field Theory: M. Peskin & D.V. Schroeder. (Levant Books).
3. Dynamics of the Standard Model: J.F. Donoghue (Cambridge University Press).

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Elective Subject -IV

MSPH-546-21	**Environmental Physics**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: Knowledge of classical physics			
Course Objectives: The aim of the course in **Environmental Physics** to expose the students to of M Sc physics to the recent advancements in this field so that they understand these aspects properly and are well equipped to pursue a career in environment physics and other related fields.			
Course Outcomes: At the end of the course, the student will be able to			

CO1	Understand the different types of pollution that occur in the Earth's environment
CO2	Apply the laws of radiation to Solar and Terrestrial Radiation
CO3	Describe the main reservoirs and exchanges in the global carbon cycle and explain the challenges involved in reducing CO2 emissions
CO4	Application in the Renewable sources of energy
CO5	Describe how pollution and climate are modelled on different scales, ranging from the local environment to the global Earth system.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	2	2	2	2	1	2	3
CO2	2	1	2	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2	2	1	2	2
CO4	1	2	1	2	2	2	2	2	2	2	-	3
CO5	1	2	2	2	2	2	2	2	2	2	2	2

Detailed syllabus:

1. **Essentials of Environmental Physics**: Structure and thermodynamics of the atmosphere, Composition of air, Greenhouse effect, Transport of matter, energy and momentum in nature, Stratification and stability of atmosphere, Lass of motion, hydrostatic equilibrium, General circulation of the topics, Elements of weather and climate of India.

2. **Solar and Terrestrial Radiation:** Physics of radiation, Interaction of light with matter, tayleigh and Mie scattering, Laws of radiation (Kirchoffs law, Planck's law, Beer's law, Wien's displacement law, etc.), Solar and terrestrial spectra, UV radiation, Ozone depletion problem, IR absorption energy balance of the earth atmosphere system.

3. **Environmental Pollution and degradation:** Elementary fluid dynamics, Diffusion, Turbulence and turbulent diffusion, Factors governing air, Water and noise pollution, Air and water quality standards, Waste disposal, Heat island effect, Land and sea breeze, Puffs and plumes, Gaseous and particulate matters, Wet and dry deposition.

4. **Environmental Changes and remote sensing:** Energy sources and combustion processes, Renewable sources of energy, Solar energy, Wind energy, bioenergy, hydropower, fuel cells, nuclear energy, Forestry and bioenergy.

5. **Global and Regional Climate:** Elements of weather and climate, Stability and vertical motion of air, Horizontal motion of air and water, Pressure gradient forces, Viscous forces, Reynolds number, Enhanced Greenhouse Effect, Energy balance-a Zero-dimensional Greenhouse model, Global climate models.

Suggested Readings/Books :

1. Egbert Boeker & Rienk Van Groundelle: Environmental Physics (John Wiley).
2. J. T Hougtion: The Physics of atmosphere (Cambrige University Press, 1977).
3. J Twidell and J Weir: Renewable energy Resources (Elbs, 1988).
4. Sol Wieder: An introduction t solar energy for scientists and Engineers (John Wiley, 1982)
5. R. N. Keshavamurthy and M. Shanker Rao: The Physics of Monsoons (Allied Publishers, 1992).
6. G.J. Haltiner and R.T. Williams: Numerical Weather Prediction (John Wiley, 1980).

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MSPH-547-21	Dissertation	L-0, T-12, P-0	12 Credits
Pre-requisite: Knowledge of specific branch of physics			
Course Objectives: The aim of the **M.Sc.** Research project work or Dissertation is to expose the students to preliminaries and methodology of research in Theoretical Physics and Experimental Physics. Students get the opportunity to participate in some ongoing research activity and development of a laboratory experiment.			
Course Outcomes: At the end of the course, the student will be able to			

CO1	Explain the significance and value of problem in physics, both scientifically and in the wider community.
CO2	Design and carry out scientific experiments as well as accurately record the results of experiments.
CO3	Critically analyse and evaluate experimental strategies, and decide which is most appropriate for answering specific questions.
CO4	Research and communicate scientific knowledge in the context of a topic related to condensed matter physics/Nuclear/High Energy Physics, in oral, written and electronic formats to both scientists and the public at large.
CO5	Explore new areas of research in physics and allied fields of science and technology.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	3	1	2	2	2	2	3	2	3
CO2	3	3	3	2	2	2	1	2	2	2	2	2
CO3	2	2	2	2	2	2		2	2	2	1	3
CO4	1	1	-	1		2	2	2	2	3	1	3
CO5	-	2	2	1	-	1		2	2		2	2

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Guidelines for the Dissertation:

The aim of project work in M.Sc. 4th semesters is to expose the students to preliminaries and methodology of research and as such it may consist of review of some research papers, development of a laboratory experiments, fabrication of a device, working out some problem, participation in some ongoing research activity, analysis of data, etc.. Project work can be based upon Experimental Physics, Theoretical Physics, or Simulation (quantum based softwares, HPCC, etc.) in the thrust as well as non-thrust research areas of the Department.

A student opting for this course will be attached to one teacher of the Department before the end of the 3rd semester. A report about the work done in the project (typed on both the sides of the paper and properly bound) will be submitted by a date to be announced by the Head of Department.

Assessment of the work done under the project will be carried out by a committee on the basis of effort put in the execution of the project, interest shown in learning the methodology, report prepared, grasp of the problem assigned and viva-voce/seminar, etc. as per course guidelines.