IK Gujral Punjab Technical University

Agenda

Board of Studies (Physical Sciences, Nano science and Engineering)

at

Department of Physical Sciences

IKG, Punjab Technical University, Kapurthala

On 16 September 2021, 11:00 AM

Agenda for the Board of Studies (Physical Sciences, Nano science and Engineering), IKGPTU to be held on 16th September 2021 at Department of Physical Sciences IK Gujral, Punjab Technical University, Kapurthala at 11:00 AM

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Agenda 7.1 To consider the Program outcomes (POs) and Course outcomes (COs) of Ph.D. courses.

The scheme and syllabus of Pre-PhD course work is already approved by the Department of Research and Development and recently a new course on Research and Publication ethics is introduced as per UGC guidelines (letter No.D.O.No.F.1-112018 (Journal/CARE). Approved copy of syllabus is attached herewith for your information. Further, directions have been received from R&D Department to frame the Program outcomes (POs) and Course outcomes of Ph.D. courses as per the requirement of NAAC. The draft of CO and PO is enclosed for consideration.

Agenda 7.2 Revision of study scheme, course codes for B.Sc. (Hons) physics

University has formed a common BOS for university campuses and affiliated colleges accordingly the uniform course scheme from 2021-22 is to be followed. Study scheme and syllabus of B.Sc. (Hons) Physics is enclosed for consideration.

Agenda 7.3 Revision of study scheme, course codes, and syllabus of M.Sc. (Physics)

Study scheme and syllabus of M.Sc. Physics was revised in BoS during 2017- 2018 and scheme was implemented in 2018 for IKGPTU Main campus and affiliated campuses. Then, minor changes were carried out in few courses by the Main/constituent campuses BoS in 2019. Now there is a combined BoS for the University campus and affiliated colleges, accordingly, the scheme for M.Sc. Physics in line with the changes carried out by the University campus BoS is placed for consideration and adoption uniformly.

Agenda 7.4 Revision of study scheme, course codes, and syllabus of various physics courses in B. Tech. programs

As per the feedback received from the various stake holders, we plan to revise the syllabus of courses on, Mechanics of Solids (BTPH-101-18), Semiconductor Physics (BTPH-104-18) and Semiconductor and Opto-electronics Physics (BTPH-105-18). Further the syllabus of Lab courses also needs minor revision. Accordingly, the course codes and syllabus of Physics courses will be updated.

Agenda 7.5 Revision of marks distribution in internal and external examination of M.Sc. Physics scheme.

Presently, we are following a 70-30 marking scheme for the internal and external evaluation for the theory courses in the University campus and affiliated campuses. We wish to change this scheme to 40-60 as the same scheme is followed in all the B.Tech. and M. Tech. courses at IKGPTU. Revised examination pattern is attached herewith.

To discuss any other agenda with the permission of Chair

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.

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. AICTE has proposed the content of lecture-based module for Bridge course in Physics. The content of bridge course comprises 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. Copy of AICTE notification is attached here as Annexure X.

Items are placed for kind consideration and approval.

I.K. GUJRAL PUNJAB TECHNICAL UNIVERSITY

Estd. Under Punjab Technical University Act, 1996
(Punjab Act No. 1 of 1997)

Ref. No. : IKGPTU/REG/NF/2172 *Dated : 27.07.2021*

NOTIFICATION

Sub: Ph.D Course work structure and criteria for assessment.

As approved by Vice Chancellor, I. K. Gujral Punjab Technical University has adopted the following Ph.D course work structure and criteria for assessment during the Ph.D degree:

Sr. No.	Nature of Course	Name of Course	Credits	Hours per week	Maximum Marks	External Marks	Internal Marks	External Assessment	Internal assessment
1	Core	Research Methodology	4	4	100	60	40	3 hours exam	MSTs, Assignments/ presentations
2	Core	Subject related theory paper	4	4	100	60	40	3 hours exam	MSTs, Assignments/ presentations
3	Core	Presentation/ Seminar	3	3	75	0	75	--	Seminar and technical report writing
4	Inter-disciplinary	Elective	4	4	100	60	40	3 hours exam	MSTs, Assignments/ presentations
5	For all streams	Research and Publication Ethics (RPE)	2	2	50	30	20	3 hours exam	MST, Assignments/ presentations

(Sandeep Kumar Kazal)
Registrar

Endst. No. IKGPTU/REG/NF/2173-2178 Dated: 27.07.2021

A copy of the above is forwarded to the following for information and necessary action please.

1. I/C VC Secretariat for kind information of Hon'ble Vice-Chancellor
2. Dean (R&D), IKGPTU
3. Director (Main Campus): To inform all Deputy Dean (Faculty), HoDs (Teaching) and Director/Incharge, Constituent Campuses
4. Controller of Examination, IKGPTU
5. Director/Principal, colleges authorized for Ph.D course work
6. In-charge (ITS): for upload of notice in the Notice Board of University website and Ph.D admissions link also

(Sandeep Kumar Kazal)
Registrar

1

I.K. GUJRAL PUNJAB TECHNICAL UNIVERSITY

Estd. Under Punjab Technical University Act, 1996
(Punjab Act No. 1 of 1997)

Ref. No. : IKGPTU/Reg/N/ *Dated :*

NOTIFICATION

Sub: **Regarding Pre-Ph.D Course work.**

This is for information of all concerned that Pre-Ph.D course work from 2016-17 will be conducted in the IKGPTU main campus Kapurthala in regular mode. The PhD course work will consists of minimum 15 credits. The structure of the course work is as under.

Sr. No.	Nature of course	Name of course	Credits	Remarks
1.	Core	1.Research Methodology	4	The syllabus of RM should be formulated faculty wise such as Engineering, Science, Management/ Humanities and Life sciences
		2.Subject related theory paper	4	Discipline specific related to advancements in theoretical methods for research
		3. Presentation	3	Discipline specific
2.	Interdisciplinary	4. Elective	4	From list of subjects from allied fields
	Total Minimum credits		**15**	

-Sd-
Registrar

Endorsement No: IKGPTU/REG/N/ 4244-4251 Dated: 22.08.2016

1. Secretary to Vice Chancellor: For kind information of Vice Chancellor
2. Dean (P&D)
3. Dean (RIC)
4. Dean (Academics)
5. Finance Officer
6. Controller of Examination
7. DR (Computers): For uploading on website
8. File Copy

19/8/16
Registrar

I. K. Gujral Punjab Technical University, Jalandhar
Jalandhar Kapurthala Highway, Near Pushpa Gujral Science City, Kapurthala - 144 603
Ph. No. 01822 - 662521, 662501 Fax No. : 01822-255506, 662526. Email : registrar@ptu.ac.in

SCHEME OF COURSES

S.NO.	Name Course	Code	L-T-P	Credits
1	Research Methodology	PHS900	3-1-0	4
2	Theoretical methods in Physics	PHS901	3-1-0	4
3	Techniques in Experimental Physics	PHS902	3-1-0	4
4	Advanced Condensed Matter Physics	PHS903	3-1-0	4
5	Computational Physics	PHS904	3-1-0	4
6	Nano Materials	PHS905	3-1-0	4

Physics

PHS900 Research Methodology

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 fitting.
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.

References:

1. Research Methods for Science by Michael P. Marde

2. The not so short introduction to LATEX by TobianOetiker, Hubert Partl, Hrene Hyna and Elisabeth Schlegl

3. T.Veerarajan and T. Ramachandran "Numerical methods" Tata McGraw Hill, New Delhi, 2008

4. Data reduction and error analysis for physical sciences by Philip R. Bevington and D. Keith Robinson

PHS901 Theoretical methods in Physics

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

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, parity 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.

Books recommended:

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)2000
4. Structure of the Nucleus by M.A. Preston and R.K. Bhadhuri.
5. Quantum Theory of Solids by C. Kittel
6. Liquid State Physics by N.H. March and M.P. Tosi
7. Quantum field theory by Lahiri and Pal

Electives

PHS902 Techniques in Experimental Physics

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.

Surface Analysis: Atomic force microscopy, Scanning, Tunneling microscopy, Secondary ion mass spectrometry, Auger electron spectroscopy, X-ray photoelectron spectroscopy, image analysis.

Thermal Analysis: Differential thermal analysis, Differential scanning calorimetry and Thermo-grayimetric analysis. Fourier transform infrared spectroscopy. Ultraviolet visible spectrophotometer.

Electron Microscopy: Interaction of electrons with solids, Scanning Electron Microscopy and specimen preparation techniques, Wavelength dispersive spectroscopy.

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).

Radiation analysis: Raman analysis and spectroscopy, Photo luminance, Photo multiplier tube, LINAC.

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.

Recommended Books:

1. Materials Characterisation, Metals Hand Book, 9th edition, Vol 10.
2. Cullity, B.D., "Elements of X-ray Diffraction", Addision Wesley Publishingh 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 Publishing Co. Bombay, 1968.
5. Brandon D.G., "Modern Techniques in Metallography", VonNostrand 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.

PHS903 Advanced Condensed Matter Physics

1. Transport Properties: Boltzmann equations, Electrical Conductivity, Calculation of relaxation time, Impurity scattering, Ideal resistance, Carrier mobility, General Transport coefficients, Thermal conductivity, Thermoelectric effects, Lattiice 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.
Quantum Hall Effect : Classical Hall effect; integral quantum Hall effect (IQHE); fractional quantum Hall effect (FQHE) and Laughlin's theory.

3. 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; nanomechanics

4. Defects and Dislocation- Lattice Vaccancies, 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.

PHS904 Computational Physics

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-variate 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 Schrödinger 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,

Books Recommended:

1. Fortran Programming – V. Rajaraman
2. Numerical Methods: A Computer Oriented Approach, BPB Publ. 1996 R.S. Salaria
3. Computer based Numerical Methods 3rd Ed. Prentice Hall India 1980, V.Rajaraman
4. Mathematica, S. Wolfram, Addison. Wesley
5. Application of the Monte Carlo Method, K. Binder, Springer Veriag
6. An Introduction to Computer Simulation Methods, H.Gould and J. Toobochnlik, Addison Wesley, 1996.
7. Computational Physics by S.E. Koonin And Meredith

PHS905 Nano Material

Synthesis and processing: Nano particles from low- pressure, Low temperature plasmas and its applications, Low temperature compaction of nanosize powders, Nanofabrications with atom optics, Processing of nanocrystalline materials. Vapour processing of nanostructured materials.

Electrical properties: Quantized states in low-dimensional systems, Self-consistent treatment of one- and two- dimensional problems, Quantum wires- magnetosize effects and weak localization; magnetophonon reaonances; vertical tunneling, Quantum dots- fabricated quantum dots; impurity dot system; energy states, Current-voltage characteristics, Vertical transport through quantum dots.

Magnetic properties: Magnetic field profile, quantum motion in nonhomogeneous magnetic fields, Diffusive transport of electrons through magnetic barriers, One- and two- dimensional magnetic modulation, Hall effect devices, Nanoscale magnets.

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

Books Recommended:

1. Nalwa, H.S. "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.

ज्ञान–विज्ञान विमुक्तये

प्रो. रजनीश जैन
सचिव

Prof. Rajnish Jain
Secretary

सत्यमेव जयते

विश्वविद्यालय अनुदान आयोग
University Grants Commission
(मानव संसाधन विकास मंत्रालय, भारत सरकार)
(Ministry of Human Resource Development, Govt. of India)

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D.O.No.F.1-1/2018(Journal/CARE) December, 2019

Respected Sir/Madam,

University Grants Commission in its 543rd meeting held on 9th August, 2019 approved two Credit Courses for awareness about publication ethics and publication misconducts entitled **"Research and Publication Ethics (RPE)"** to be made compulsory for all Ph.D. students for pre-registration course work **(attached as Annexure).**

In view of the above, you are requested to ensure that the above two Credit courses may be made compulsory for all Ph.D. students for pre-registration course work undertaken in your University from the forthcoming academic session.

With regards,

Yours sincerely,

(Rajnish Jain)

TO THE VICE-CHANCELLORS OF ALL UNIVERSITIES

ANNEXURE

Course Title:

- **Research and Publication Ethics (RPE)**-Course for awareness about the publication ethics and publication misconducts.

Course Level:

- 2 Credit course (30 hrs.)

Eligibility:

- M.Phil., Ph.D. students and interested faculty members (It will be made available to post graduate students at later date)

Fees:

- As per University Rules

Faculty:

- Interdisciplinary Studies

Qualifications of faculty members of the course:

- Ph.D. in relevant subject areas having more than 10 years' of teaching experience

About the course

Course Code: CPE- RPE

Overview

- This course has total 6 units focusing on basics of philosophy of science and ethics, research integrity, publication ethics. Hands-on-sessions are designed to identify research misconduct and predatory publications. Indexing and citation databases, open access publications, research metrics (citations, h-index, Impact Factor, etc.) and plagiarism tools will be introduced in this course.

Pedagogy:

- Class room teaching, guest lectures, group discussions, and practical sessions.

Evaluation

- Continuous assessment will be done through tutorials, assignments, quizzes, and group discussions. Weightage will be given for active participation. Final written examination will be conducted at the end of the course.

Course structure

- The course comprises of six modules listed in table below. Each module has 4-5 units.

Modules	Unit title	Teaching hours
Theory		
RPE 01	Philosophy and Ethics	4
RPE 02	Scientific Conduct	4
RPE 03	Publication Ethics	7
Practice		
RPE 04	Open Access Publishing	4
RPE 05	Publication Misconduct	4
RPE 06	Databases and Research Metrics	7
	Total	**30**

Syllabus in detail

THEORY

- **RPE 01: PHILOSOPHY AND ETHICS (3 hrs.)**

1. Introduction to philosophy: definition, nature and scope, concept, branches
2. Ethics: definition, moral philosophy, nature of moral judgements and reactions

- **RPE 02: SCIENTIFICCONDUCT (5hrs.)**

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data

- **RPE 03: PUBLICATION ETHICS (7 hrs.)**

1. Publication ethics: definition, introduction and importance
2. Best practices / standards setting initiatives and guidelines: COPE, WAME, etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types
5. Violation of publication ethics, authorship and contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

PRACTICE

- **RPE 04: OPEN ACCESS PUBLISHING(4 hrs.)**

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

- **RPE 05: PUBLICATION MISCONDUCT (4hrs.)**

A. Group Discussions (2 hrs.)

1. Subject specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools (2 hrs.)

Use of plagiarism software like Turnitin, Urkund and other open source software tools

- **RPE 06: DATABASES AND RESEARCH METRICS (7hrs.)**

A. Databases (4 hrs.)

1. Indexing databases
2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics (3 hrs.)

1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
2. Metrics: h-index, g index, i10 index, altmetrics

References

Bird, A. (2006). *Philosophy of Science*. Routledge.
MacIntyre, Alasdair (1967) *A Short History of Ethics.* London.
P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN:978-9387480865
National Academy of Sciences, National Academy of Engineering and Institute of Medicine. (2009). *On Being a Scientist: A Guide to Responsible Conduct in Research: Third Edition.* National Academies Press.
Resnik, D. B. (2011). What is ethics in research & why is it important. *National Institute of Environmental Health Sciences*, 1–10. Retrieved from https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm
Beall, J. (2012). Predatory publishers are corrupting open access. Nature, 489(7415), 179–179. https://doi.org/10.1038/489179a
Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance(2019), ISBN:978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics_Book.pdf

Annexure II

Pre- Ph.D.

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

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 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.

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**

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. apply concepts of research methods and methodologies to the physics problems,
CO2	Work with different types of documents, organize them into different sections, subsections, implicate various formatting types and write complex mathematical formulae using the latex.
CO3	Handle data, plot graphs, draw flow charts, survey research related problems and infer data using Origin
CO4	identify and define appropriate research problem and prepare a research proposal accordingly
CO5	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	3	1	3	3	3	3	3	3

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.

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 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 be able to			

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

Detailed Syllabus:

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

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)2000
4. Structure of the Nucleus by M.A. Preston and R.K Bhadhuri.
5. Quantum Theory of Solids by C. Kittel
6. Liquid State Physics by N.H. March and M.P. Tosi
7. Quantum field theory by Lahiri and Pal, Narosa Publishing house

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 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 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	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	2	2	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

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-grayometric 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 K-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.
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 lnterscience, 1971.
4. Cherepin and Malik, “Experimental Techniques in Physical Metallurgy:, Asia Publishing Co. 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.

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

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.

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.

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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	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

Detailed Syllabus:

1. Introduction to simulation approach: Introduction to modeling and simulationMethods 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 lsing model and atomic fluids, simulation methods for quantum-mechanical problems, time-dependent Schrodinger equation, discussion of selected problemsinPhysics, nonlinear dynamics, diffusion-limited aggregation and transport properties, etc. Introduction to parallel computation, Physical Simulations: N body methods and particle simulations.

Text Books:

1. Fortran Programming, V. Rajaraman
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,
5. Application of the Monte Carlo Method, K. Binder, Springer Veriag
6. An Introduction to Computer Simulation Methods, H.Gould and J. Toobochnlik, Addison Wesley, 1996.
7. Computational Physics, S.E. Koonin andMeredith, Westview Press, 1998.

PHS 904	**Computational 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 **Research methodology** is to equip the Ph.D. 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 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	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

Detailed Syllabus:

1. Synthesis and processing: Nano particles from low- pressure, Low temperature plasmas and its applications, Low temperature compaction of nanosize powders, Nanofabrication atomic optics, Processing of nanocrystalline materials. Vapour processing of nanostructured materials.

2. Electrical properties: Quantized states in low-dimension systems, Self-consistent treatment of one- and two- dimensional problems, Quantum wires- metasized effects and weak localization; magnetophonon resonances; vertical tunneling, Quantum dots-fabricated quantum dots; impurity dot system; energy states, Current-voltage characteristics Vertical transport through quantum dots.

3. Magnetic properties: Magnetic field profile, quantum moon in nonhomogeneous magnetic fields, Diffusive transport of electrons through magnetic barrel, One- and two- dimensional magnetic modulation, Hall effect devices, Nanoscale magnets.

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.

PHS906	Advanced Particle Physics	L-3, T-1, P-0	4 Credits

Pre-requisite: Knowledge of particle physics

Course Objectives: The objective of the course on **Advanced Particle Physics** is to expose the students of Ph.D. 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 have

CO1	Understanding of 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	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	Physics beyond the Standard Model 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	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

Detailed Syllabus:

1. **Symmetries and Symmetry Breaking in QFT:** Continuous groups: Lorentz group SO(1,2) and its representations, Dirac, Weyl and Majorana fermions, 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 and Decoupling, 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, 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).

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	-	1	1	-	2	1	1	2
CO2	3	3	2	1	-	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	3	-	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)*

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).*

PHS 901	Research and Publication ethics	L-3, T-1, P-0	4 Credits
Pre-requisite: Understanding of post graduate level physics and research			
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 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 be able to			

CO1	Familiarizing with moral philosophy of Research Ethics
CO2	To acquire knowledge on definition, concept and problems that lead to unethical behaviour in research
CO3	The students will understand predatory publishers and journals
CO4	Students can learn how to search relevant journals and research papers using online resources
CO5	Identify the challenging problems in research integrity and intellectual honesty.

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	2	3	3	3	3

Detailed syllabus as per UGC guidelines (letter No.D.O.No.F.1-112018 (Journal/CARE)

B.Sc. (Hons.) Physics

Course Structure and Syllabus
(Based on Choice Based Credit System)
2019 onwards

Bachelor of Sciences (Hons) Physics Program

Duration: 3 Years (Semester System)

Eligibility: The prospective student must have 10+2 or equivalent with minimum 50% marks or equivalent in aggregate with Physics as one of the main subjects. A relaxation for the minimum marks will be as per Punjab government regulations.

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 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.

SEMESTER FIRST

Course Code	Course Title	Type of course	Load Allocation			Marks Distribution		Total Marks	Cr
			L	T	P	Internal	External		
UC-BSHP-111-19	Optics	**Core Course Theory and Practical**	4	-	-	40	60	100	4
UC-BSHP-112-19	Electricity and Magnetism		4	-	-	40	60	100	4
UC-BSHP-113-19	Physics Lab-I		-	-	4	30	20	50	2
UC-BSHM 104-19	Calculus-I	**General Elective and Practical**	4	1	-	40	60	100	4
UC-BHCL-I-101-19	Inorganic Chemistry		4	1	-	40	60	100	4
UC-BHCP-I-102-19	Chemistry Lab-I		-	-	4	30	20	50	2
UC-BSHL-105-19	Communicative English -I	**Ability Enhancement Compulsory Course**	2	-	-	20	30	50	2
UC-BSHL-106A/106B-19	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

SEMESTER SECOND

Course Code	Course Title	Type of course	Load Allocation			Marks Distribution		Total Marks	Cr
			L	T	P	Internal	External		
UC-BSHP-121-19	Waves and Vibrations	**Core Course Theory and Practical**	**4**	**-**	**-**	**40**	**60**	**100**	**4**
UC-BSHP-122-19	Mechanics		**4**	**-**	**-**	**40**	**60**	**100**	**4**
UC-BSHP-123-19	Physics Lab-II		**-**	**-**	**4**	**30**	**20**	**50**	**2**
UC-BSHM-XXX-19	Mathematics	**General Elective and Practical**	**4**	**1**	**-**	**40**	**60**	**100**	**4**
UC-BSHC-XXX-19	Organic Chemistry		**4**	**1**	**-**	**40**	**60**	**100**	**4**
UC-BSHC-XXX-19	Chemistry Lab-II		-	-	**4**	**30**	**20**	**50**	**2**
UC-BSHX-XXX-19	Communicative English -II	**Ability Enhancement Compulsory Course**	**2**	**-**	**-**	**20**	**30**	**50**	**2**
UC-BSHX-XXX-19	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

Annexure-IV

B.Sc. (Hons.) Physics

Study Scheme

(Based on Choice Based Credit System)

2021 onwards

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	Electricity and Magnetism		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
BHHL-105-21	Communicative English -I	**Ability Enhancement Compulsory Course**	2	-	-	20	30	50	2
BHHL-106A-21 BHH-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

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	Mechanics		**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**
BHHL-205-21	Communicative English -II	**Ability Enhancement Compulsory Course**	**2**	**-**	**-**	**20**	**30**	**50**	**2**
BHHL-206A-21 BHHL-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

M.Sc. Physics

Course Structure and Syllabus
(Based on Choice Based Credit System)
2018 onwards

IK Gujral Punjab Technical University

VISION

To be an institution of excellence in the domain of higher technical education that serves as the fountainhead for nurturing the future leaders of technology and techno- innovation responsible for the techno-economic, social, cultural and environmental prosperity of the people of the State of Punjab, the Nation and the World

MISSION

- To provide seamless education through the pioneering use of technology, in partnership with industry and society with a view to promote research, discovery and entrepreneurship and
- To prepare its students to be responsible citizens of the world and the leaders of technology and techno-innovation of the 11st Century by developing in them the desirable knowledge, skill and attitudes base for the world of work and by instilling in them a culture for seamlessness in all facets of life.

OBJECTIVES

- To offer globally-relevant, industry-linked, research-focused, technology- enabled seamless education at the graduate, postgraduate and research levels in various areas of engineering & technology and applied sciences keeping in mind that the manpower so spawned is excellent in quality, is relevant to the global technological needs, is motivated to give its best and is committed to the growth of the Nation;
- To foster the creation of new and relevant technologies and to transfer them to industry for effective utilization;
- To participate in the planning and solving of engineering and managerial problems of relevance to global industry and to society at large by conducting basic and applied research in the areas of technologies;

- To develop and conduct continuing education programmes for practicing engineers and managers with a view to update their fundamental knowledge base and problem-solving capabilities in the various areas of core competence of the University;
- To develop strong collaborative and cooperative links with private and public sector industries and government user departments through various avenues such as undertaking of consultancy projects, conducting of collaborative applied research projects, manpower development programmes in cutting-edge areas of technology, etc;
- To develop comprehensive linkages with premier academic and research institutions within the country and abroad for mutual benefit;
- To provide leadership in laboratory planning and in the development of instructional resource material in the conventional as well as in the audio-visual, the video and computer-based modes;
- To develop programmes for faculty growth and development both for its own faculty as well as for the faculty of other engineering and technology institutions;
- To anticipate the global technological needs and to plan and prepare to cater to them;
- To interact and participate with the community/society at large with a view to inculcate in them a feel for scientific and technological thought and endeavour; and
- To actively participate in the technological development of the State of Punjab through the undertaking of community development programmes including training and education programmes catering to the needs of the unorganized sector as well as that of the economically and socially weaker sections of society.

ACADEMIC PHILOSOPHY

The philosophy of the education to be imparted at the University is to awaken the **"deepest potential"** of its students as holistic human beings by nurturing qualities of self-confidence, courage, integrity, maturity, versatility of mind as well as a capacity to face the challenges of tomorrow so as to enable them to serve humanity and its highest values in the best possible way.

DEPARTMENT OF PHYSICAL SCIENCES

VISION

To be a knowledge nerve center in Physical Sciences, Pure and Applied Research and industry requirements for creating sustainable infrastructure and enhancing quality of life

MISSION

1. To offer globally-relevant, industry-linked, research-focused, technology-enabled seamless education at the graduate, postgraduate and research levels in various areas of Physical sciences keeping in mind that the manpower so spawned is excellent in quality, is relevant to the global scientific and technological needs, is motivated to give its best and is committed to the growth of the Nation;
2. To develop and conduct continuing education programmes for Science graduates with a view to update their fundamental knowledge base and problem-solving capabilities in the various areas of core specialization of the University;
3. To develop comprehensive linkages with premier academic and research institutions within the country and abroad for mutual benefit.

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	To 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		
MSPH411-18	Mathematical Physics-I	3	1	-	30	70	100	4
MSPH412-18	Classical Mechanics	3	1	-	30	70	100	4
MSPH413-18	Quantum Mechanics-I	3	1	-	30	70	100	4
MSPH414-18	Electronics	3	1	-	30	70	100	4
MSPH415-18	Computational Physics	3	1	-	30	70	100	4
MSPH416-18	Electronics Lab	-	-	6	50	25	75	3
MSPH417-18	Computational Physics Lab-I	-	-	6	50	25	75	3
TOTAL		15	5	12	250	400	650	26

SEMESTER SECOND

Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Credits
		L	T	P	Internal	External		
MSPH421-18	Mathematical Physics-II	3	1	-	30	70	100	4
MSPH422-18	Statistical Mechanics	3	1	-	30	70	100	4
MSPH423-18	Quantum Mechanics-II	3	1	-	30	70	100	4
MSPH424-18	Classical Electrodynamics	3	1	-	30	70	100	4
MSPH425-18	Atomic and Molecular Physics	3	1	-	30	70	100	4
MSPH426-18	Atomic, Nuclear, and Particle Physics Lab	-	-	6	50	25	75	3
MSPH427-18	Computational Physics Lab-II	-	-	6	50	25	75	3
	TOTAL	15	5	12	250	400	650	26

L: Lectures T: Tutorial P: Practical

SEMESTER THIRD

Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Credits
		L	T	P	Internal	External		
MSPH531-18	Condensed Matter Physics	3	1	-	30	70	100	4
MSPH532-18	Nuclear Physics	3	1	-	30	70	100	4
MSPH533-18	Particle Physics	3	1	-	30	70	100	4
MSPH534-18 MSPH535-18 MSPH536-18	Elective Subject-I	3	1	-	30	70	100	4
MSPH537-18 MSPH538-18 MSPH539-18	Elective Subject-II	3	1	-	30	70	100	4
MSPH540-18	Condensed Matter Physics Lab	-	-	6	50	25	75	3
TOTAL		**15**	**5**	**6**	**200**	**375**	**575**	**23**

SEMESTER FOURTH

Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Credits
		L	T	P	Internal	External		
MSPH541-18 MSPH542-18 MSPH543-18	Elective Subject-III	3	1	-	30	70	100	4
MSPH544-18 MSPH545-18 MSPH546-18	Elective Subject-IV	3	1	-	30	70	100	4
MSPH547-18	Dissertation	12			200	100	300*	12
TOTAL		**6**	**14**		**260**	**240**	**500**	**20**

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

TOTAL NUMBER OF CREDITS = 95

LIST OF DEPARTMENTAL/INTERDISCIPLINARY ELECTIVES

Elective Subject-I

S. No.	Name of the Subject	Code
1	Fibre optics and non-linear optics	MSPH534-18
2	Radiation Physics	MSPH535-18
3	Nonlinear Dynamics	MSPH536-18

Elective Subject -II

S.No.	Name of the Subject	Code
1	Plasma Physics	MSPH537-18
2	Structures, Spectra and Properties of Biomolecules	MSPH538-18
3	Science of Renewable Source of Energy	MSPH539-18

Elective-III

S.No.	Name of the Subject	Code
1	Physics of Nanomaterials	MSPH541-18
2	Experimental Techniques in Nuclear and Particle Physics	MSPH542-18
3	Superconductivity and Low Temperature Physics	MSPH543-18

Elective-IV

	Name of the Subject	Code
1	Advanced Condensed Matter Physics	MSPH544-18
2	Advanced Particle Physics	MSPH545-18
3	Environment Physics	MSPH546-18

Examination and Evaluation

Theory			
S. No.	**Evaluation criteria**	**Weightage in Marks**	**Remarks**
1	Mid term/sessional Tests	20	Internal evaluation (20 Marks) MSTs, Quizzes, assignments, attendance, etc., constitute internal evaluation. Average of two mid semester test will be considered for evaluation.
2	Attendance	5	
3	Assignments	5	
4	End semester examination	70	External evaluation (70 Marks) Conduct and checking of the answer sheets will at the Department level in case of University teaching Department or Autonomous institutions. For other colleges examination will be conducted at the University level.
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.

<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.

MSPH411-18	**MATHEMATICAL PHYSICS-I**	**L-3, T-1, P-0**	**4 Credits**

Pre-requisite: Understanding of graduate level mathematics

Course Objectives: The objective of the course on **Mathematical Physics-I** 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 be able to

CO1	Use complex variables for solving definite integral.
CO2	Use the Delta and Gamma functions for describing physical systems.
CO3	Solve partial differential equations using boundary value problems.
CO4	Describe special functions and recurrence relations to solve the physics problems.
CO5	Use statistical methods to analyse 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	-	1	1	-	2	1	1	2
CO2	3	3	2	1	-	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	3	-	2	1	-	2	1	1	2

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) 2rd 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) 2rd ed., 2006.*

MSPH412-18	**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 problem (like motion under central force, periodic motions) 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
CO2	3	2	2	2	2	1	1	-	2	2	2	2
CO3	3	2	2	2	2	1	1	-	2	2	2	2
CO4	3	2	2	2	1	1	1	-	2	2	2	2
CO5	3	2	2	2	1	1	1	-	2	2	2	2

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),* 2rd ed 2001.
2. Mechanics by L.D. Landau & E.M. Lifschz (Pergamon), 1976.

Reference Books:

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

MSPH413-18	**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 problems, generalized uncertainty principle in QM.
CO3	Better understanding of the mathematical foundations of spin and angular momentum for a system of particles.
CO4	Solve Schrodinger equation for various QM systems using approximate methods.
CO5	Apply perturbation theory to scattering matrix and partial wave analysis.

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

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 12)*

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 7)*

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 7)*

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)*

5. **Scattering Theory:** Scattering Cross-section and scattering amplitude, partial wave analysis, Low energy scattering, Green’s functions in scattering theory, Born approximation and its application to Yukawa potential and other simple potentials. Optical theorem, Scattering of identical particles. *(Lectures 7)*

Text Books:

1. A Text book of Quantum Mechanics: P.M. Mathews and K. Venkatesan (Tata McGraw Hill, New Delhi) 1nd 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), 2rd ed. 2002.
5. Quantum Physics: Concepts and Applcations: Nouredine Zettili (Wiley, New York), 2nd ed. 2009.

MSPH414-18	**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

Detailed Syllabus:

1. **Semiconductor Devices and applications:** Direct and indirect semiconductors, Drift and diffusion of carriers, Photoconductors, Semiconductor junctions, Metal-semiconductor junctions - Ohmic and rectifying contacts, Zener diode, Schottky diode, Switching diodes, Tunnel diode, Light emitting diodes, Photodiodes, Solar cell, Liquid crystal displays. *(Lectures 7)*
2. **UJTs and Thyristors:** Operational Principle of UJT: UJT Relaxation Oscillator circuit; PNPN Diode: Characteristics- As a Relaxation Oscillator-Rate Effect; SCR: V-I Characteristics-Gate Triggering Characteristics; DIAC and TRIAC; Thyristors: Basic Parameters- As Current Controllable Devices- Thyristors in Series and in Parallel; Applications of Thyristors- as a Pulse Generator, Bistable Multivibrator, Half and Full Wave Controlled Rectifier, TRIAC based AC power control, SCR based Crowbar Protection; Gate Turn-Off Thyristors; Programmable UJT. *(Lectures 10)*
3. **Analog and Digital Instruments:** OPAMP and its applications, Time Base; 555 Timer, Basic Digital Frequency Meter System; Reciprocal Counting Technique; Digital Voltmeter System. *(Lectures 8)*
4. **Digital circuits:** Boolean algebra, de Morgans theorem, Karnaugh maps. *(Lectures 5)*

5. **Sequential circuits:** Flip-Flops – RS, JK, D, COcked, preset and clear operation, race around conditions in JK Flip-flops, master-slave JK flip-flops, Switch contact bounce circuit. Shift registers, Asynchronous and Synchronous counters, Counter design and applications. *(Lectures8)*
6. **Integrated Circuits as Digital System Building Blocks:** Binary Adders: Half Adder-Parallel Operation-Full Adder-MSI Adder-Serial Operation; Decoder/Demultiplexer: BCD to Decimal Decoder-4-to-16 line Demultiplexer; Data Selector/Multiplexer:16-to-1 Multiplexer; Encoder; ROM: Code Converters-Programming the ROM-Applications; RAM:Linear Selection-Coincident Selection-Basic RAM Elements Bipolar RAM-Static and Dynamic MOS RAM; Digital to Analog Converters: Ladder Type D/A Converter-Multiplying D/A Converter; Analog to Digital Converters: Successive Approximation A/D Converter. *(Lectures 8)*

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,* 1nd Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2010.

MSPH415-18	**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 (Matlab/Mathematica/Scilab/Octave), input/output, interactive input, loading and saving data, loops branches and control flow, Matrices and Vectors, Matrix and array operations, Graphic tools: Gnuplots, Origin, Sigmaplot, Visual Molecular Dynamics, Mathematica, etc. *(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. *(Lectures15)*

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) 1nd edition, 2011.

Reference Books:

1. Computer Applications in Physics: S. Chandra (Narosa) 1nd 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.

MSPH416-18	**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

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*, 1st Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2010.

MSPH417-18	**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

Detailed Syllabus:

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

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) 1nd edition, 2011.

Reference Books:

1. Computer Applications in Physics: S. Chandra (Narosa) 1nd 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.

MSPH421-18	**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.

MSPH422-18	**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), 2rd 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) 1nd edition, 2011*.
3. Elementary Statistical Physics: *C. Kittel (Wiley, New York), 2004.*
4. Statistical Mechanics: *S.K. Sinha (Tata McGraw Hill, New Delhi), 1990.*

MSPH423-18	**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 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

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.

MSPH424-18	**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 and apply the laws of electromagnetism and use Maxwell equations in different forms and different media.
CO2	Explain the dynamics of charged bodies and radiation from localized time varying electromagnetic sources.
CO3	Provide solution to real life plane wave problems for various boundary conditions for different charge configurations.
CO4	Describe the propagation of electromagnetic waves and its propagation through different media types /configurations.
CO5	To develop an understanding about the waveguides, and propagation of waves through different waveguides.

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

Detailed Syllabus:

1. **Electrostatics:** Laplace and Poisson's equations, Electrostatic potential and energy density of the electromagnetic field, Multipole expansion of the scalar potential of a charge distribution, dipole moment, quadrupole moment, Multipole expansion of the energy of a charge distribution in an external field, Static fields in material media, Polarization vector, macroscopic equations, classification of dielectric media, Molecular polarizability and electrical susceptibility, Clausius-Mossetti relation, Models of Molecular polarizability, energy of charges in dielectric media (Maxwell stress tensor). *(Lectures 10)*
2. **Magnetostatics:** The differential equations of magnetostatics, vector potential, magnetic fields of a localized current distribution, Singularity in dipole field, Fermi-contact term, Force and torque on a localized current distribution. (Magnetic stress tensor) *(Lectures 8)*
3. **Boundary value problems:** Uniqueness theorem, Dirichlet and Neumann Boundary conditions, Earnshaw theorem, Green's (reciprocity) theorem, Formal solution of electrostatic boundary value problem with Green function, Method of images with examples, Magnetostatic boundary value problems. *(Lectures 8)*
4. **Time varying fields and Maxwell equations:** Faraday's law of induction, displacement current, Maxwell equations, scalar and vector potential, Gauge transformation, Lorentz and Coulomb gauges, Hertz potential, General expression for the electromagnetic fields energy, conservation of energy, Poynting Theorem, Conservation of momentum. *(Lectures 8)*
5. **Electromagnetic Waves:** wave equation, plane waves in free space and isotropic dielectrics, polarization, energy transmitted by a plane wave, Poynting theorem for a complex vector field, waves in conducting media, skin depth, Reflection and refraction of e.m. waves at plane interface, Fresnel's amplitude relations, Reflection and Transmission coefficients, polarization by reflection, Brewster's angle, Total internal reflection, Stoke's parameters, EM wave guides, Cavity resonators, Dielectric waveguide, optical fibre waveguide. *(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) 1nd edition,1986*.
3. Electromagnetic Field Theory Fundamentals: *Bhag Singh Guru and H.R. Hiziroglu*

MSPH425-18	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

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.*

MSPH426-18	**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.*

MSPH427-18	**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

Detailed Syllabus:

1. Write a program to study graphically the EM oscillations in a 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 and without air drag using FN method. Find the horizontal and maximum height in either case. Write your comments on the findings.
4. Study the motion of an artificial satellite.
5. Study the motion of (a) 1-D harmonic oscillator (without and with damping effects).(b) 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.
6. To obtain the energy eigenvalues of a quantum oscillator using the Runge-Kutta method.
7. Study the motion of a charged particle in: (a) Uniform electric field, (b) Uniform Magnetic field, (c) in combined uniform electric and magnetic fields. Draw graphs in each case.
8. Use Monte Carlo techniques to simulate phenomenon of (i) Nuclear Radioactivity. Do the cases in which the daughter nuclei are also unstable with half life greater/lesser than the parent nucleus. (ii) to determine solid angle in a given geometry. (iii) simulate attenuation of gamma rays/neutron in an absorber and (iv) solve multiple integrals and compare results with Simpson's method.
9. To study phase trajectory of a Chaotic Pendulum.
10. 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), 1nd 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), 1nd 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 McGrawHill), 5th ed. 2011.

MSPH531-18	**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

Detailed Syllabus:

1. **Crystal binding and Elastic constants:** Binding in solids; Cohesive energy, Crystals of Inert gases, ionic crystal, Covalent Crystals, Analysis of elastic strains: dilation, stress components; Elastic Compliance and Stiffness: elastic constants, elastic waves in cubic crystals. (Lectures 6)
2. **Lattice Dynamics and Thermal Properties:** Vibrations of crystal with monatomic and two atom per primitive Basis; Quantization of Elastic waves, Phonon momentum; Inelastic scattering by phonons, Phonon Heat Capacity, Planck Distribution, normal modes; Density of states, Debye T2 model; Einstein Model; anharmonic crystal interactions; thermal conductivity expansion. (Lectures 9)
3. **Energy Band Theory:** Electrons in a periodic potential: Bloch theorem, Nearly free electron model; Kronig Penney Model; Electron in a periodic potential; tight binding method; Wigner-Seitz Method Semiconductor Crystals, Band theory of pure and doped semiconductors; effective mass elementary idea of semiconductor superlattices. (Lectures 9)
4. **Transport Theory:** Electronic transport from classical kinetic theory; Introduction to Boltzmann transport equation; electrical and thermal conductivity of metals; thermoelectric effects; Hall effect and magneto resistance. (Lectures 8)
5. **Dielectrics and Ferro Electrics:** Polarization mechanisms, Dielectric function from oscillator strength, Clausius-Mosotti relation; piezo, pyro- and ferro-electricity; Dipole theory of ferroelectricity; thermodynamics of ferroelectric transition. (Lectures 8)

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), 1nd ed. 1991.*

MSPH532-18	**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. **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)*

2. **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)*

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 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)*

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.*

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) 1nd ed (2011).*
3. Nuclear Physics and its applications: *John Lile*
4. Nuclear Physics: *V. Devnathan*

MSPH533-18	**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

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

Reference Books:

1. Elementary Particles : I.S. Hughes (Cambridge University Press), 2rded. 1991.
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.
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

MSPH534-18	**Fibre Optics and Non-linear optics**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: Understanding of graduate level optics			
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

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-otpic 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.*

Elective Subject -I

MSPH535-18	**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 and their use for spectroscopy.		
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

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 8)

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 8)
3. **Nuclear Detectors and Spectroscopy:** 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 8)
4. **Nuclear spectrometry and applications:** Analysis of nuclear spectrometric data, Measurements of nuclear energy levels, spins, parities, moments, internal conversion coefficients, Angular correlation, Perturbed angular correlation, Measurement of g-factors and hyperfine fields. *(Lectures 8)*

5. **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 Mossbauer effect, Rutherford backscattering. Applications of elemental analysis, Diagnostic nuclear medicine, Therapeutic nuclear medicine.
(Lectures 8)

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

MSPH536-18	**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.

Elective Subject -II

MSPH537-18	**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*

Elective Subject-II

MSPH538-18	**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

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

MSPH539-18	**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

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).*

MSPH540-18	**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), 1nd ed. 1991.*

Elective Subject -III

MSPH541-18	**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. **Preparation 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. **Other Nanomaterials:** Properties and applications of carbon nanotubes and nanofibres, Nanosized metal particles, Nanostructured polymers, Nanostructured films and Nano structured semiconductors. *(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. Nanoparticles and Nanostructured Films–Preparation, Characterization and Application: *J.H.Fendler (Wiley), 1998.*
3. Nanofabrication and Bio-system: *H.C. Hoch, H.G. Craighead and L. Jelinski (Cambridge Univ. Press), 1996.*
4. Physics of Semiconductor Nanostructures*: K.P. Jain (Narosa), 1997*.
5. Physics of Low-Dimension Semiconductors*: J.H. Davies (Cambridge Univ. Press) 1998.*
6. Advances in Solid State Physics (Vo.41): *B. Kramer (Ed.) (Springer), 2001.*

Elective Subject -III

MSPH542-18	**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 various statistical methods for experimental data.
CO3	Knowledge about the different types of the radiation detectors and their applications.
CO4	Introduced to neutron physics, methods to detector slow and fast neutrons.
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. General properties of Radiation detectors, energy resolution, detection efficiency and dead time. Statistics and treatment of experimental data. *(Lectures 8)*

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

3. **Applications of Detectors:** Description of electron and gamma ray spectrum from detector, semiconductor detectors in X- and gamma-ray spectroscopy, Compton-suppressed, 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

MSPH543-18	**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

MSPH544-18	**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

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), 2rd. 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

MSPH545-18	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).

Elective Subject -IV

MSPH546-18	**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).

MSPH547-18	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

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.

Annexure-VI

M.Sc. Physics

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

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

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

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

Examination and Evaluation

Theory			
S. No.	**Evaluation criteria**	**Weightage in Marks**	**Remarks**
1	Mid term/sessional Tests	24	Internal evaluation (30 Marks) MSTs, Quizzes, assignments, attendance, etc., constitute internal evaluation. Average of two mid semester test will be considered for evaluation.
2	Attendance	6	
3	Assignments	10	
4	End semester examination	60	External evaluation (70 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.

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.

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	

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><th colspan="5">Total</th><th>300</th><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.

MSPH-411-21	**MATHEMATICAL PHYSICS-I**	**L-3, T-1, P-0**	**4 Credits**

Pre-requisite: Understanding of graduate level mathematics

Course Objectives: The objective of the course on **Mathematical Physics-I** 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 be able to

CO1	Use complex variables for solving definite integral.
CO2	Use the Delta and Gamma functions for describing physical systems.
CO3	Solve partial differential equations using boundary value problems.
CO4	Describe special functions and recurrence relations to solve the physics problems.
CO5	Use statistical methods to analyse 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	-	1	1	-	2	1	1	2
CO2	3	3	2	1	-	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	3	-	2	1	-	2	1	1	2

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.*

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
CO2	3	2	2	2	2	1	1	-	2	2	2	2
CO3	3	2	2	2	2	1	1	-	2	2	2	2
CO4	3	2	2	2	1	1	1	-	2	2	2	2
CO5	3	2	2	2	1	1	1	-	2	2	2	2

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.

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

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.

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

Detailed Syllabus:

1. **Semiconductor Devices and applications:** Direct and indirect semiconductors, Drift and diffusion of carriers, Photoconductors, Semiconductor junctions, Metal-semiconductor junctions - Ohmic and rectifying contacts, Zener diode, Schottky diode, Switching diodes, Tunnel diode, Light emitting diodes, Photodiodes, Solar cell, Liquid crystal displays. *(Lectures 7)*
2. **UJTs and Thyristors:** Operational Principle of UJT: UJT Relaxation Oscillator circuit; PNPN Diode: Characteristics- As a Relaxation Oscillator-Rate Effect; SCR: V-I Characteristics-Gate Triggering Characteristics; DIAC and TRIAC; Thyristors: Basic Parameters- As Current Controllable Devices- Thyristors in Series and in Parallel; Applications of Thyristors- as a Pulse Generator, Bistable Multivibrator, Half and Full Wave Controlled Rectifier, TRIAC based AC power control, SCR based Crowbar Protection; Gate Turn-Off Thyristors; Programmable UJT. *(Lectures 10)*
3. **Analog and Digital Instruments:** OPAMP and its applications, Time Base; 555 Timer, Basic Digital Frequency Meter System; Reciprocal Counting Technique; Digital Voltmeter System. *(Lectures 8)*
4. **Digital and Sequential circuits:** Boolean algebra, de Morgans theorem, Karnaugh maps, Flip-Flops – RS, JK, D, COcked, preset and clear operation, race around conditions in JK Flip-flops, master-slave JK flip-flops, Switch contact bounce circuit. Shift registers, Asynchronous and Synchronous counters, Counter design and applications. *(Lectures 8)*
5. **Integrated Circuits as Digital System Building Blocks:** Binary Adders: Half Adder-Parallel Operation-Full Adder-MSI Adder-Serial Operation; Decoder/Demultiplexer: BCD to Decimal Decoder-4-to-16 line Demultiplexer; Data Selector/Multiplexer:16-to-1 Multiplexer; Encoder; ROM: Code Converters-Programming the ROM-Applications; RAM:Linear Selection-Coincident Selection-Basic RAM Elements Bipolar RAM-Static and Dynamic MOS RAM; Digital to Analog Converters: Ladder Type D/A Converter-Multiplying D/A Converter; Analog to Digital Converters: Successive Approximation A/D Converter. *(Lectures 8)*

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.

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.) 6^{th} ed., 1979.
2. A first course in Computational Physics: P.L. DeVries (Wiley) 2^{nd} edition, 2011.

Reference Books:

1. Computer Applications in Physics: S. Chandra (Narosa) 2^{nd} 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

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.

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

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.

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. *S*tatistical Mechanics: *S.K. Sinha (Tata McGraw Hill, New Delhi), 1990.*

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

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

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*

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

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.*

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.*

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

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.

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

Detailed Syllabus:

1. **Crystal binding and Elastic constants:** Binding in solids; Cohesive energy, Crystals of Inert gases, ionic crystal, Covalent Crystals, Analysis of elastic strains: dilation, stress components; Elastic Compliance and Stiffness: elastic constants, elastic waves in cubic crystals. (Lectures 6)
2. **Lattice Dynamics and Thermal Properties:** Vibrations of crystal with monatomic and two atom per primitive Basis; Quantization of Elastic waves, Phonon momentum; Inelastic scattering by phonons, Phonon Heat Capacity, Planck Distribution, normal modes; Density of states, Debye T2 model; Einstein Model; anharmonic crystal interactions; thermal conductivity expansion. (Lectures 9)
3. **Energy Band Theory:** Electrons in a periodic potential: Bloch theorem, Nearly free electron model; Kronig Penney Model; Electron in a periodic potential; tight binding method; Wigner-Seitz Method Semiconductor Crystals, Band theory of pure and doped semiconductors; effective mass elementary idea of semiconductor superlattices. (Lectures 9)
4. **Transport Theory:** Electronic transport from classical kinetic theory; Introduction to Boltzmann transport equation; electrical and thermal conductivity of metals; thermoelectric effects; Hall effect and magneto resistance. (Lectures 8)
5. **Dielectrics and Ferro Electrics:** Polarization mechanisms, Dielectric function from oscillator strength, Clausius-Mosotti relation; piezo, pyro- and ferro-electricity; Dipole theory of ferroelectricity; thermodynamics of ferroelectric transition. (Lectures 8)

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.*

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

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

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.*

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

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.

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*

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

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

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).*

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

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).

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 CO_2 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).

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

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.

Semester 1st

Sr. No.	Branch	Related Branches	Course codes	Course title	Credits
1	Civil Engineering	1. Civil Engineering	BTPH101-18	Mechanics of solids	4
		2.Construction Engineering & Management	BTPH111-18	Mechanics of solids Lab	1.5
2	Electrical Engineering	1.Electrical Engineering	BTPH102-18	Optics and Modern Physics	4
		2.Automation & Robotics			
		3.Electrical & Electronics Engineering	BTPH112-18	Optics and Modern Physics Lab	1.5
		4.Electronics & Electrical Engineering			
		5.Electrical Engineering & Industrial Control			
		6.Instrumentation & Control Engineering			
3	Mechanical Engineering	1.Mechanical Engineering	BTPH103-18	Electromagnetism	4
		2.Marine Engineering	BTPH113-18	Electromagnetism Lab	1.5
		3.Production Engineering			
		4.Industrial Engineering			
		5.Tool Engineering			
		6.Automobile Engineering			
		7.Aerospace Engineering			
		8.Aeronautical Engineering			

4	Computer Science Engineering	1.Computer Engineering 2.Computer Science Engineering 3.Information Technology 4.3D Animation Engineering 5 CSE (Artificial Intelligence & Machine Learning 6 CSE (Data Science) 7 CSE(IoT & Cyber Security including Block Chain Technology) 8 CSE (Internet of Things) 9 Artificial Intelligence & Data Science	BTPH104-18 BTPH114-18	Semiconductor Physics Semiconductor Physics Lab	4 1.5
5	Electronics and communication Engineering	1.Electronics & Communication Engineering 2.Electronics & Computer Engineering 3.Electronics & Instrumentation Engineering 4.Electronics & Telecomm Engineering 5.Electronics Engineering	BTPH105-18 BTPH115-18	Semiconductor and Optoelectronics Physics Semiconductor and Optoelectronics Physics Lab	4 1.5
6	Chemical Sciences	1.Chemical Engineering 2.Petrochem & Petroleum Refinery Engineering 3.Textile Engineering 4.Food Technology	BTPH106-18 BTPH116-18	Optics and Electromagnetism Optics and Electromagnetism Lab	4 1.5

7	Bio-Technology	1 Bio-Technology 2 Agricultural Engineering	BTPH107-18 BTPH117-18	Introduction to Physics: Biotechnology Physics Lab	4 1.5

BTPH101-18	**Mechanics of Solids**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisites (if any): High-school education with Physics as one of the subject.			
Course Objectives: The aim and objective of the course on **Mechanics of Solids** is to introduce the students of B. Tech. 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.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Understand the vector mechanics for a classical system.		
CO2	Identify various types of forces in nature, frames of references, and conservation laws.		
CO3	Know the simple harmonic, damped, and forced simple harmonic oscillator for a mechanical system.		
CO4	Analyze the planar rigid body dynamics for a mechanical system.		
CO5	Apply the knowledge obtained in this course to the related problems.		

Detailed Syllabus:

PART-A

UNIT I: Vector mechanics ***(10 lectures)***

Physical significance of gradient, Divergence and curl. Potential energy function, F = - Grad V, equipotential surfaces, Forces in Nature, Newton's laws and its completeness in describing particle motion, Conservative and non-conservative forces, curl of a force field; Central forces; Conservation of Angular Momentum and Energy, Introduction to Cartesian, spherical and cylindrical coordinate system, Inertial and Non-inertial frames of reference; Rotating coordinate system :- Centripetal and Coriolis accelerations.

UNIT II: Simple harmonic motion, damped and forced simple harmonic oscillator ***(10 lectures)***

Mechanical simple harmonic oscillators, damped oscillations, damped harmonic oscillator – heavy, critical and light damping, energy decay in a damped harmonic oscillator, quality factor, forced mechanical oscillators, resonance.

PART-B

UNIT III: Planar rigid body mechanics ***(10 lectures)***

Definition and motion of a rigid body in plane; Rotation in the plane, Angular momentum about a point of a rigid body in planar motion; center of mass, moment of inertia, theorems of moment of inertia, inertia of plane lamina, circular ring, moment of force, couple, Euler's laws of motion.

UNIT IV: Mechanics of solids ***(10 lectures)***

Friction: Definitions: Types of friction, Laws of static friction, Limiting friction, Angle of friction, angle of repose; motion on horizontal and inclined planes. Methods of reducing friction, Concept of stress and strain at a point; Concepts of elasticity, plasticity, strain hardening, failure (fracture/yielding), one dimensional stress-strain curve; Generalized Hooke's law. Force analysis — axial force, shear force, bending moment and twisting moment. Bending stress; Shear stress; Concept of strain energy; Yield criteria.

Reference books and suggested reading:

1. Engineering Mechanics, 2nd ed. - MK Harbola, Cengage Learning India, 2013.
2. Introduction to Mechanics - MK Verma, CRC Press Book, 2009.
3. Mechanics- DS Mathur, S Chand Publishing, 1981.
4. An Introduction to Mechanics - D Kleppner & R Kolenkow, Tata McGraw Hill 2009.
5. Principles of Mechanics - JL Synge & BA Griffiths, Nabu Press, 2011.
6. Mechanics - JP Den Hartog, Dover Publications Inc, 1961.
7. Engineering Mechanics- Dynamics, 7th ed. - JL Meriam, Wiley.
8. Theory of Vibrations with Applications -WT Thomson, Pearson.
9. An Introduction to the Mechanics of Solids, 2nd ed. with SI Units-SH Crandall, NC Dahl & TJ Lardner
10. Classical Mechanics- H. Goldstein, Pearson Education, Asia.
11. Classical mechanics of particles and rigid bodies-K.C Gupta, Wiley eastern, New Delhi.
12. Engineering Physics-Malik and Singh, Tata McGraw Hill.
13. Engineering Mechanics: Statics- 7th ed.-JL Meriam, Wiley, 2011.
14. Analytical Mechanics-Satish K Gupta, Modern Publishers.
15. https://nptel.ac.in/courses/122102004/

BTPH111-18	**Mechanics of Solids Lab**	**L-0, T-0, P-3**	**1.5 Credits**

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

Course Objectives: The aim and objective of the Lab course on **Mechanics of Solids** is to introduce the students of B. Tech to the formal structure of Mechanics of solids so that they can use these in Engineering as per their requirement.

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

CO1	Able to understand the concepts learned in the mechanics of solids.
CO2	Learning the skills needed to verify some of the concepts of theory courses.
CO3	Trained in carrying out precise measurements and handling sensitive equipment.
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.

Detailed syllabus:

Note: Students are expected to perform about 10-12 experiments from the following list, selecting minimum of 7-8 from the Section-A and 3-4 from the Section-B.

Section -A

1. Measurements of length (or diameter) using vernier caliper, screw gauge, and travelling microscope. Use of Plumb line and Spirit level.
2. To determine the horizontal distance between two points using a Sextant.
3. To determine the vertical distance between two points using a Sextant.
4. To determine the height of an inaccessible object using a Sextant.
5. To determine the angular diameter of the sun using the sextant.
6. To determine the angular acceleration α, torque τ, and Moment of Inertia of flywheel.
7. To study the Motion of a Spring and calculate (a) Spring Constant (b) Value of **g** and (c) Modulus of rigidity.
8. To determine the time period of a simple pendulum for different length and acceleration due to gravity.
9. 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.
10. To determine the Young's Modulus of a Wire by Optical Lever Method.
11. To determine the Elastic Constants/Young’s Modulus of a Wire by Searle’s method.
12. To determine the Modulus of Rigidity of a Wire by Maxwell’s needle.
13. To determine the Modulus of Rigidity of brass using Searle’s method.
14. To find the moment of inertia of an irregular body about an axis through its C.G with the torsional pendulum.
15. To determine **g** by Kater’s Pendulum.
16. To determine **g** and velocity for a freely falling body using Digital Timing Technique.
17. To find out the frequency of AC mains using electric-vibrator.

Section-B

Virtual lab:

1. To determine the angular acceleration α and torque τ of flywheel.
2. To determine the moment of inertia of a flywheel.
3. To find the acceleration of the cart in the simulator.
4. To find the distance covered by the cart in the simulator in the given time interval.
5. To verify that energy conservation and momentum conservation can be used with a ballistic pendulum to determine the initial velocity of a projectile, its momentum and kinetic energy.
6. To verify the momentum and kinetic energy conservation using collision balls.
7. To understand the torsional oscillation of pendulum in different liquid. and determine the rigidity modulus of the suspension wire using torsion pendulum.
8. To find the Time of flight, Horizontal range and maximum height of a projectile for different velocity, angle of projection, cannon height and environment.
9. The Elastic and Inelastic collision simulation will help to analyse the collision variations for different situations.
10. Demonstration of collision behaviour for elastic and inelastic type.
11. Variation of collision behavior in elastic and inelastic type.
12. Study of variation of Momentum, Kinetic energy, Velocity of collision of the objects and the Center of Mass with different velocity and mass.
13. Calculation of the Momentum, Kinetic energy, and Velocity after collision.

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. Laboratory Experiments in College Physics, C.H. Bernard and C.D. Epp, John Wiley and Sons, Inc., New York, 1995.
7. Practical Physics, G.L. Squires, Cambridge University Press, Cambridge, 1985.
8. Experiments in Modern Physics, A.C. Melissinos, Academic Press, N.Y., 1966.
9. Practical Physics, C L Arora. S. Chand & Company Ltd.
10. http://www.vlab.co.in
11. http://vlab.amrita.edu/index.php?sub=1

BTPH102-18	Optics and Modern Physics	L-3, T-1, P-0	4 Credits

Pre-requisite (if any):

1. High-school education with physics as one of the subject.
2. Mathematical course on differential equations.

Course Objectives: The aim and objective of the course on **Optics and Modern Physics** is to introduce the students of B.Tech. to the subjects of wave optics, Quantum Mechanics, Solids, and Semiconductors so that they can use these in Engineering as per their requirement.

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 wave phenomena.
CO2	Understand optical phenomenon, such as, interference, diffraction etc. in terms of wave model.
CO3	Understand the importance of wave equation in nature and appreciate the mathematical formulation of the same.
CO4	Appreciate the need for quantum mechanics, wave particle duality, uncertainty principle etc. and their applications.
CO5	Understand some of the basic concepts in the physics of solids and semiconductors.

Detailed Syllabus:

PART-A

UNIT I: Waves and Oscillations ***(10 lectures)***

Mechanical simple harmonic oscillators, damped harmonic oscillator, forced mechanical oscillators, impedance, steady state motion of forced damped harmonic oscillator, Transverse wave on a string, wave equation on a string, reflection and transmission of waves at a boundary, impedance matching, standing waves, longitudinal waves and their wave equation, reflection and transmission of waves at a boundary.

UNIT II: Optics and LASERS ***(10 lectures)***

Optics: Light as an electromagnetic wave, reflectance and transmittance, Fresnel equations (Qualitative idea), Brewster's angle, total internal reflection: Interference: Huygens' principle, superposition of waves and interference of light by wavefront splitting and amplitude splitting; Young's double slit experiment, Michelson interferometer. Diffraction: Farunhofer diffraction from a single slit and a circular aperture, Diffraction gratings and their resolving power; LASERS: Spontaneous and stimulated emission, Einstein's theory of matter radiation interaction and A and B coefficients; population inversion, pumping, various modes, properties of laser beams, types of lasers: gas lasers (He-Ne), solid-state lasers (ruby), and its applications.

PART-B

UNIT III: Introduction to Quantum Mechanics ***(10 lectures)***

Wave nature of Particles, Free-particle wave function and wave-packets, probability densities, Expectation values, Uncertainty principle, Time-dependent and time-independent Schrodinger equation for wave function, Born interpretation, Solution of stationary-state Schrodinger equation for one dimensional problems: particle in a box, linear harmonic oscillator.

UNIT IV: Introduction to Solids and Semiconductors ***(10 lectures)***

Free electron theory of metals, Fermi level, density of states in 1, 2 and 3 dimensions, Bloch's theorem for particles in a periodic potential, Origin of energy bands (Qualitative idea); Types of electronic materials: metals, semiconductors, and insulators, Intrinsic and extrinsic semiconductors, Dependence of Fermi level on carrier-concentration and temperature (equilibrium carrier statistics), Carrier generation and recombination, Carrier transport: diffusion and drift, p-n junction.

Reference books and suggested reading:

1. I. G. Main, "Vibrations and waves in physics", Cambridge University Press, 1993.
2. H. J. Pain, "The physics of vibrations and waves", Wiley, 2006.
3. E. Hecht, "Optics", Pearson Education, 2008.
4. A. Ghatak, "Optics", McGraw Hill Education, 2012.
5. O. Svelto, "Principles of Lasers", Springer Science & Business Media, 2010.
6. D. J. Griffiths, "Quantum mechanics", Pearson Education, 2014.
7. R. Robinett, "Quantum Mechanics", OUP Oxford, 2006.
8. D.A. Neamen, "Semiconductor Physics and Devices", Times Mirror High Education Group, Chicago, 1997.
9. E.S. Yang, "Microelectronic Devices", McGraw Hill, Singapore, 1988.
10. B.G. Streetman, "Solid State Electronic Devices", Prentice Hall of India, 1995.
11. HK Malik and AK Singh, Engineering Physics, 2nd ed., Tata McGraw Hill, 2018.
12. S. Sharma and J. Sharma, Engineering Physics, Pearson, 2018.
13. https://nptel.ac.in/courses/117108037/3
14. https://nptel.ac.in/courses/115102023/

BTPH112-18	Optics and Modern Physics Lab	L-0, T-0, P-3	1.5 Credits

Pre-requisite (If any): High-school education with physics as one of the subject.

Course Objectives: The aim and objective of the lab on **Optic and Modern Physics** is to introduce the students of B.Tech. class to the formal structure of wave and optics, Quantum Mechanics and semiconductor physics so that they can use these in Engineering branch as per their requirement.

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

CO1	Verify some of the theoretical concepts learnt in the theory courses.
CO2	Trained in carrying out precise measurements and handling sensitive equipment.
CO3	Introduced to 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	Write a technical report which communicates scientific information in a clear and concise manner.

Detailed Syllabus:

Note: Students are expected to perform about 10-12 experiments from the following list, selecting minimum of 7-8 from the Section-A and 3-4 from the Section-B.

Section-A

1. To study the laser beam characteristics like; wave length using diffraction grating aperture & divergence.
2. Study of diffraction using laser beam and thus to determine the grating element.
3. To study laser interference using Michelson's Interferometer.
4. To determine the numerical aperture of a given optic fibre and hence to find its acceptance angle.
5. To determine attenuation & propagation losses in optical fibres.
6. To determine the grain size of a material using optical microscope.
7. To find the refractive index of a material/glass using spectrometer.
8. To find the refractive index of a liquid using spectrometer.
9. To find the velocity of ultrasound in liquid.
10. To determine the specific rotation of sugar using Laurent's half-shade polarimeter.
11. To study the characteristic of different p-n junction diode - Ge and Si.
12. To analyze the suitability of a given Zener diode as voltage regulator.
13. To find out the intensity response of a solar cell/Photo diode.
14. To find out the intensity response of a LED.
15. To find out the frequency of AC mains using electric-vibrator.

Section-B

Virtual lab:

1. To find the resolving power of the prism.
2. To determine the angle of the given prism.
3. To determine the refractive index of the material of a prism
4. To determine the numerical aperture of a given optic fibre and hence to find its acceptance angle.
5. To calculate the beam divergence and spot size of the given laser beam.
6. To determine the wavelength of a laser using the Michelson interferometer.
7. To revise the concept of interference of light waves in general and thin-film interference in particular.
8. To set up and observe Newton's rings.
9. To determine the wavelength of the given source.
10. To understand the phenomenon Photoelectric effect.
11. To draw kinetic energy of photoelectrons as a function of frequency of incident radiation.
12. To determine the Planck's constant from kinetic energy versus frequency graph.
13. To plot a graph connecting photocurrent and applied potential.
14. To determine the stopping potential from the photocurrent versus applied potential graph.

Reference books and suggested reading:

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. Laboratory Experiments in College Physics, C.H. Bernard and C.D. Epp, John Wiley and Sons, Inc., New York, 1995.
7. Practical Physics, G.L. Squires, Cambridge University Press, Cambridge, 1985.
8. Experiments in Modern Physics, A.C. Melissinos, Academic Press, N.Y., 1966.
9. Practical Physics, C L Arora. S. Chand & Company Ltd.
10. http://www.vlab.co.in
11. http://vlab.amrita.edu/index.php?sub=1

BTPH103-18	Electromagnetism	L-3, T-1, P-0	4 Credits

Pre-requisites (if any):

1. High-school education with physics as one of the subject.
2. Mathematical course on vector calculus.

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

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

CO1	Specify the constitutive relationships for fields and understand their important.
CO2	Describe the static and dynamic electric and magnetic fields for technologically important structures.
CO3	Measure the voltage induced by time varying magnetic flux.
CO4	acquire the knowledge of Maxwell equation and electromagnetic field theory and propagation and reception of electro-magnetic wave systems.
CO5	have a solid foundation in engineering fundamentals required to solve problems and also to pursue higher studies.

Detailed Syllabus:

PART-A

UNIT I: Electrostatics in vacuum and linear dielectric medium ***(10 lectures)***

Calculation of electric field and electrostatic potential for a charge distribution; Divergence and curl of electrostatic field; Laplace's and Poisson's equations for electrostatic potential; Uniqueness theorem (Definition); examples: Faraday's cage; Boundary conditions of electric field; Energy of a charge distribution and its expression in terms of electric field. Electrostatic field and potential of a dipole. Bound charges due to electric polarization in Dielectrics; Electric displacement; Solving simple electrostatics problems in presence of dielectrics – Point charge at the centre of a dielectric sphere, charge in front of a dielectric slab.

UNIT II: Magnetostatics in linear magnetic medium ***(10 lectures)***

Bio-Savart law, Divergence and curl of static magnetic field; Concept of vector potential, Magnetization and associated bound currents; auxiliary magnetic field $\vec{H}$; Boundary conditions on $\vec{B}$ and $\vec{H}$. Solving for magnetic field due to bar magnet; magnetic susceptibility and ferromagnetic, paramagnetic and diamagnetic materials; magnetic domains, hysteresis and B-H curve.

PART-B

UNIT III: Faraday's law and Maxwell's equations *(10 lectures)*

Faraday's law; equivalence of Faraday's law and motional EMF; Lenz's law; Electromagnetic breaking and its applications; Differential form of Faraday's law; energy stored in a magnetic field. Continuity equation for current densities; Modifying equation for the curl of magnetic field to satisfy continuity equation; displacement current and magnetic field arising from time-dependent electric field; Maxwell's equation in vacuum and non-conducting medium; Flow of energy and Poynting vector and Poynting theorem.

UNIT IV: Electromagnetic waves *(10 lectures)*

Wave equation for electromagnetic waves in free space and conducting medium, Uniform plane waves and general solution of uniform plane waves, relation between electric and magnetic fields of an electromagnetic wave their transverse nature.; Linear, circular and elliptical polarization, Reflection and transmission of electromagnetic waves from a non-conducting medium-vacuum interface for normal incidence.

Text and Reference Books:

1. D. Griffiths, Introduction to Electrodynamics, Pearson Education India; 4th ed. (2015).
2. J D Jackson, Classical Electrodynamics, John Wiley and Sons (1999).
3. Halliday and Resnick, Fundamentals of Physics, Wiley (2011).
4. W. Saslow, Electricity, Magnetism and Light, Academic Press (2002).
5. HK Malik and AK Singh, Engineering Physics, 2nd ed., Tata McGraw Hill (2018).

BTPH113-18	**Electromagnetism Lab**	**L-0, T-0, P-3**	**1.5 Credits**

Pre-requisite (If any): High-school education

Course Objectives: The aim and objective of the lab course on **Electromagnetism** is to introduce the students of B. Tech. class to the formal structure of electromagnetism so that they can use these in various branches of engineering as per their requirement.

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

CO1	Able to verify some of the theoretical concepts learnt in the 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	Write a technical report which communicates scientific information in a clear and concise manner.

Detailed Syllabus:

Note: Students are expected to perform about 10-12 experiments from the following list, selecting minimum of 7-8 from the Section-A and 3-4 from the Section-B.

Section-A

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 magnetic field of a circular coil carrying current.
3. To study B-H curve for a ferromagnetic material using CRO.
4. To find out the frequency of AC mains using electric-vibrator.
5. To find out polarizability of a dielectric substance.
6. Determine a high resistance by leakage method using Ballistic Galvanometer.
7. To study the characteristics of a Series RC Circuit.
8. To study the series LCR circuit and determine its (a) Resonant Frequency, (b) Quality.
9. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency (b) Quality factor Q.
10. To determine the value of self-inductance by Maxwell Inductance Bridge.
11. To determine the value of self-inductance by Maxwell Inductance Capacitance Bridge.
12. To determine the mutual inductance of two coils by Absolute method.
13. To study the induced emf as a function of the velocity of magnet and to study the phenomenon of electromagnetic damping.
14. To determine unknown capacitance by flashing and quenching method.
15. To study the field pattern of various modes inside a rectangular waveguide.
16. To determine charge to mass ratio (e/m) of an electron by helical method.
17. To determine charge to mass ratio (e/m) of an electron by Thomson method.
18. To find out the horizontal component of earth's magnetic field (B_h).

Section-B

Virtual lab:

1. To find out the horizontal component of earth's magnetic field (B_h).
2. An experiment to study the variation of magnetic field with distance along the axis of a circular coil carrying current.
3. Aim is to find the horizontal intensity of earth's magnetic field at a place and moment of the bar magnet.
4. To determine the self-inductance of the coil (L) using Anderson's bridge.
5. To calculate the value of inductive reactance (X_L) of the coil at a particular frequency.
6. The temperature coefficient of resistor simulation will help the user to easily identify the change in resistivity of the resistor according to the change in temperature.

Reference books and suggested reading:

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. Laboratory Experiments in College Physics, C.H. Bernard and C.D. Epp, John Wiley and Sons, Inc., New York, 1995.
7. Practical Physics, G.L. Squires, Cambridge University Press, Cambridge, 1985.
8. Experiments in Modern Physics, A.C. Melissinos, Academic Press, N.Y., 1966.
9. Practical Physics, C L Arora, S. Chand & Company Ltd.
10. http://www.vlab.co.in
11. http://vlab.amrita.edu/index.php?sub=1

BTPH104-18	**Semiconductor Physics**	**L-3, T-1, P-0**	**4 Credits**

Prerequisite (if any): Introduction to Quantum Mechanics desirable

Course Objectives: The aim and objective of the course on **Semiconductor Physics** is to introduce the students of B. Tech. class to the formal structure of semiconductor physics so that they can use these in Engineering as per their requirement.

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

CO1	Understand and explain the fundamental principles and properties of electronic materials and semiconductors
CO2	Understand and describe the interaction of light with semiconductors in terms of fermi golden rule.
CO3	Understand and describe the impact of solid-state device capabilities and limitations on electronic circuit performance.
CO4	Understand the design, fabrication, and characterization techniques of Engineered semiconductor materials.
CO5	Develop the basic tools with which they can study and test the newly developed devices and other semiconductor applications.

Detailed Syllabus:

PART-A

UNIT 1: Electronic materials *(10 lectures)*

Free electron theory of metals, Density of states in 1D, 2D, and 3D, Bloch's theorem for particles in a periodic potential, Energy band diagrams, Kronig-Penny model (to introduce origin of band gap), Energy bands in solids, E-k diagram, Direct and indirect bandgaps, Types of electronic materials: metals, semiconductors, and insulators, Occupation probability, Fermi level, Effective mass.

UNIT II: Semiconductors *(10 lectures)*

Intrinsic and extrinsic semiconductors, Dependence of Fermi level on carrier-concentration and temperature (equilibrium carrier statistics), Carrier generation and recombination, Carrier transport: diffusion and drift, p-n junction, Metal-semiconductor junction (Ohmic and Schottky), Semiconductor materials of interest for optoelectronic devices.

PART-B

UNIT III: Light-semiconductor interaction *(10 lectures)*

Optical transitions in bulk semiconductors: absorption, spontaneous emission, and stimulated emission; Einstein coefficients, Population inversion, application in semiconductor Lasers; Joint density of states, Density of states for phonons, Transition rates (Fermi's golden rule), Optical loss and gain; Photovoltaic effect, Exciton, Drude model.

UNIT IV: Measurement Techniques ***(10 lectures)***

Measurement for divergence and wavelength using a semiconductor laser, Measurements for carrier density, resistivity, hall mobility using Four-point probe and van der Pauw method, Hot-point probe measurement, capacitance-voltage measurements, parameter extraction from diode I-V characteristics.

Reference books and suggested reading:

1. J. Singh: Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc. (1995).
2. B. E. A. Saleh and M. C. Teich: Fundamentals of Photonics, John Wiley & Sons, Inc., (2007).
3. S. M. Sze: Semiconductor Devices: Physics and Technology, Wiley (2008).
4. A. Yariv and P. Yeh, Photonics: Optical Electronics in Modern Communications, Oxford University Press, New York (2007).
5. P. Bhattacharya: Semiconductor Optoelectronic Devices, Prentice Hall of India (1997).
6. Ben G. Streetman: Solid State Electronics Devices, Pearson Prentice Hall.
7. D.A. Neamen, "Semiconductor Physics and Devices", Times Mirror High Education Group, Chicago, 1997.
8. E.S. Yang, "Microelectronic Devices", McGraw Hill, Singapore, 1988.
9. Online course: "Semiconductor Optoelectronics" by M R Shenoy on NPTEL.
10. Online course: "Optoelectronic Materials and Devices" by Monica Katiyar and Deepak Gupta on NPTEL.

BTPH114-18	Semiconductor Physics Lab	L-0, T-0, P-3	1.5 Credits

Pre-requisite (if any): (i) High-school education

Course Objectives: The aim and objective of the Lab course on **Semiconductor Physics** is to introduce the students of B.Tech. class to the formal structure of semiconductor physics so that they can use these in Engineering as per their requirement.

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

CO1	Able to verify some of the theoretical concepts learnt in the theory courses.
CO2	Trained in carrying out precise measurements and handling sensitive equipment.
CO3	Introduced to 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	Write a technical report which communicates scientific information in a clear and concise manner.

Detailed Syllabus:

Note: Students are expected to perform about 10-12 experiments from the following list, selecting minimum of 7-8 from the Section-A and 3-4 from the Section-B.

Section-A

1. To study the characteristic of different PN junction diode-Ge and Si.
2. To analyze the suitability of a given Zener diode as a power regulator.
3. To find out the intensity response of a solar cell/Photo diode.
4. To find out the intensity response of a LED.
5. To determine the band gap of a semiconductor.
6. To determine the resistivity of a semiconductor by four probe method.
7. To confirm the de Broglie equation for electrons.
8. To study voltage regulation and ripple factor for a half-wave and a full-wave rectifier without and with different filters.
9. To study the magnetic field of a circular coil carrying current.
10. To find out polarizability of a dielectric substance.
11. To study B-H curve of a ferro-magnetic material using CRO.
12. To find out the frequency of AC mains using electric-vibrator.
13. To find the velocity of ultrasound in liquid.
14. To study the Hall effect for the determination of charge current densities.
15. Distinguish between Diamagnetic material, Paramagnetic and ferromagnetic material.
16. Measurement of susceptibility of a liquid or a solution by Quincke's method.
17. To study the sample with the nano-scale objects and measure surface topography with different scales, width and height of nano objects, and force-distance curves using AFM.
18. To study the temperature coefficient of Resistance of copper.
19. To determine the ratio k/e Using a transistor.
20. To compare various capacitance and verify the law of addition of capacitance.
21. To determine dipole moment of an organic molecule acetone.
22. To measure the temperature dependence of a ceramic capacitor.
23. Verification of the curie Weiss law for the electrical susceptibility of a ferromagnetic material.
24. To study the laser beam characteristics like; wave length using diffraction grating aperture & divergence.

25. To study laser interference using Michelson's Interferometer.
26. Study of diffraction using laser beam and thus to determine the grating element.

Section-B

Virtual lab:

1. To draw the static current-voltage (I-V) characteristics of a junction diode.
2. To plot the characteristics of thermistor and hence find the temperature coefficient of resistance.
3. To determine the resistivity of semiconductors by Four Probe Method.
4. To study Zener diode voltage as regulator and measure its line and load regulation.
5. To study the B-H Curve for a ferromagnetic material.
6. To study the Hall effect experiment to determine the charge carrier density.
7. To determine the magnetic susceptibilities of paramagnetic liquids by Quincke's Method.
8. To study the phenomena of magnetic hysteresis and calculate the retentivity, coercivity and saturation magnetization of a material using a hysteresis loop tracer.
9. Verification and design of combinational logic using AND, OR, NOT, NAND and XOR gates.

Reference books and suggested reading:

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. Laboratory Experiments in College Physics, C.H. Bernard and C.D. Epp, John Wiley and Sons, Inc., New York, 1995.
7. Practical Physics, G.L. Squires, Cambridge University Press, Cambridge, 1985.
8. Experiments in Modern Physics, A.C. Melissinos, Academic Press, N.Y., 1966.
9. Practical Physics, C L Arora, S. Chand & Company Ltd.
10. http://www.vlab.co.in
11. http://vlab.amrita.edu/index.php?sub=1

BTPH105-18	**Semiconductor and Optoelectronics Physics**	**L-3, T-1, P-0**	**4 Credits**

Prerequisite (if any): "Introduction to Quantum Mechanics" Desirable

Course Objectives: The aim and objective of the course on **Semiconductor and Optoelectronics Physics** is to introduce the students of B. Tech. class to the formal structure of semiconductor physics and Optoelectronics so that they can use these in Engineering as per their requirement.

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

CO1	Understand and explain the fundamental principles and properties of electronic materials and semiconductors.
CO2	Understand and describe the interaction of light with semiconductors in terms of fermi golden rule.
CO3	Understand and describe the impact of solid-state device capabilities and limitations on electronic circuit performance.
CO4	Understand the design, fabrication, characterization techniques, and measurements of Engineered semiconductor materials.
CO5	Learn the basics of the optoelectronic devices, LEDs, semiconductor lasers, and photo detectors.

Detailed Syllabus:

PART-A

UNIT -I: Electronic materials ***(10 lectures)***

Free electron theory of metals, Density of states in 1D, 2D, and 3D, Bloch's theorem for particles in a periodic potential, energy band diagrams, Kronig-Penny model (to introduce origin of band gap), Energy bands in solids, E-k diagram, Direct and indirect band gaps, Types of electronic materials: metals, semiconductors and insulators, Occupation probability, Fermi level, Effective mass of electron and hole.

UNIT -II: Semiconductors ***(10 lectures)***

Intrinsic and extrinsic semiconductors, Dependence of Fermi level on carrier-concentration and temperature (equilibrium carrier statistics), Carrier generation and recombination, Carrier transport: diffusion and drift, p-n junction, Metal-semiconductor junction (Ohmic and Schottky).

PART-B

UNIT -III: Optoelectronic devices *(10 lectures)*

Radiative and non-radiative recombination mechanisms in semiconductors, Semiconductor materials of interest for optoelectronic devices; Semiconductor light emitting diodes (LEDs): light emitting materials, device structure, characteristics; Optical transitions in bulk semiconductors: absorption, spontaneous emission, and stimulated emission, Semiconductor laser: population inversion at a junction, structure, materials, device characteristics, Photovoltaics: Types of semiconductor photo detectors-p-n junction, PIN, and Avalanche-and their structure, materials, working principle, and characteristics, Noise limits on performance.

UNIT-IV: Measurement techniques *(10 lectures)*

Measurement for divergence and wavelength using a semiconductor laser, Measurements for carrier density, resistivity, and hall mobility using Four-point probe and van der Pauw method, Hot-point probe measurement, capacitance-voltage measurements, parameter extraction from diode I-V characteristics.

Reference books and suggested reading:

1. J. Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc. (1995).
2. B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc. (2007).
3. S. M. Sze, Semiconductor Devices: Physics and Technology, Wiley (2008).
4. A. Yariv and P. Yeh, Photonics: Optical Electronics in Modern Communications, Oxford University Press, New York (2007).
5. P. Bhattacharya: Semiconductor Optoelectronic Devices, Prentice Hall of India (1997).
6. Solid state electronics devices: Ben. G. Streetman Pearson Prentice Hall.
7. D.A. Neamen: “Semiconductor Physics and Devices”, Times Mirror High Education Group, Chicago, 1997.
8. E.S. Yang: “Microelectronic Devices”, McGraw Hill, Singapore, 1988.
9. Online course: “Semiconductor Optoelectronics” by M R Shenoy on NPTEL.
10. Online course: "Optoelectronic Materials and Devices" by Monica Katiyar and Deepak Gupta on NPTEL.

BTPH115-18	Semiconductor and Optoelectronics Physics Lab	L-0, T-0, P-3	1.5 Credits

Pre-requisite (if any): High-school education

Course Objectives: The aim and objective of the Lab course on **Semiconductor and Optoelectronics Physics** is to introduce the students of B.Tech. class to the formal lab structure of semiconductor physics so that they can use these in Engineering as per their requirement.

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

CO1	Able to verify some of the theoretical concepts learnt in the theory courses.
CO2	Trained in carrying out precise measurements and handling sensitive equipment.
CO3	Introduced to 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	Write a technical report which communicates scientific information in a clear and concise manner.

Detailed Syllabus:

Note: Students are expected to perform about 10-12 experiments from the following list, selecting minimum of 7-8 from the Section-A and 3-4 from the Section-B.

Section-A

1. To study the characteristic of different PN junction diode-Ge and Si.
2. To analyze the suitability of a given Zener diode as a power regulator.
3. To find out the intensity response of a solar cell/Photo diode.
4. To find out the intensity response of a LED.
5. To determine the band gap of a semiconductor.
6. To determine the resistivity of a semiconductor by four probe method.
7. To confirm the de Broglie equation for electrons.
8. To study voltage regulation and ripple factor for a half-wave and a full-wave rectifier without and with different filters.
9. To study the magnetic field of a circular coil carrying current.
10. To find out polarizability of a dielectric substance.
11. To study B-H curve of a ferro-magnetic material using CRO.
12. To find out the frequency of AC mains using electric-vibrator.
13. To find the velocity of ultrasound in liquid.
14. To study the Hall effect for the determination of charge current densities.
15. Distinguish between diamagnetic material, paramagnetic and ferromagnetic material.
16. Measurement of susceptibility of a liquid or a solution by Quincke's method.
17. To study the sample with the nano-scale objects and measure surface topography with different scales, width and height of nano objects, and force-distance curves using AFM.
18. To study the temperature coefficient of Resistance of copper.
19. To determine the ratio k/e using a transistor.
20. To compare various capacitance and verify the law of addition of capacitance.
21. To measure the temperature dependence of a ceramic capacitor.
22. Verification of the curie Weiss law for the electrical susceptibility of a ferromagnetic material.

23. To study the laser beam characteristics like; wave length using diffraction grating aperture & divergence.
24. To study laser interference using Michelson's Interferometer.
25. Study of diffraction using laser beam and thus to determine the grating element.

Section-B

Virtual lab:

1. To draw the static current-voltage (I-V) characteristics of a junction diode.
2. To plot the characteristics of thermistor and hence find the temperature coefficient of resistance.
3. To determine the resistivity of semiconductors by Four Probe Method.
4. To study Zener diode voltage as regulator and measure its line and load regulation.
5. To study the B-H Curve for a ferromagnetic material.
6. To study the Hall effect experiment to determine the charge carrier density.
7. To determine the magnetic susceptibilities of paramagnetic liquids by Quincke's Method.
8. To study the phenomena of magnetic hysteresis and calculate the retentivity, coercivity and saturation magnetization of a material using a hysteresis loop tracer.
9. Verification and design of combinational logic using AND, OR, NOT, NAND and XOR gates.

Reference books and suggested reading:

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. Laboratory Experiments in College Physics, C.H. Bernard and C.D. Epp, John Wiley and Sons, Inc., New York, 1995.
7. Practical Physics, G.L. Squires, Cambridge University Press, Cambridge, 1985.
8. Experiments in Modern Physics, A.C. Melissinos, Academic Press, N.Y., 1966.
9. Practical Physics, C L Arora, S. Chand & Company LTD.
10. http://www.vlab.co.in
11. http://vlab.amrita.edu/index.php?sub=1

BTPH106-18	Optics and Electromagnetism	L-3, T-1, P-0	4 Credits

Prerequisite (if any): Introduction to Quantum Mechanics desirable

Course Objectives: The aim and objective of the course on **Optics and Electromagnetism** is to introduce the students of B.Tech. class to the basic concepts of optics and its applications, electricity and magnetism, and quantum physics, so that they can use these in Engineering as per their requirement.

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

CO1	Identify and illustrate physical concepts and terminology used in optics and other wave phenomena.
CO2	Understand optical phenomena such as polarization, birefringence, interference, and diffraction in terms of the wave model.
CO3	Understand the importance of wave equation in nature and appreciate the mathematical formulation of the same
CO4	Acquire knowledge about the Maxwell equation and magnetic properties of materials.
CO5	Appreciate the need for quantum mechanics, wave particle duality, uncertainty principle etc.

Detailed syllabus:

PART-A

Unit I: Wave Optics (*8 lectures*)

Diffraction: Introduction to interference and example; concept of diffraction, Fraunhofer and Fresnel diffraction, Fraunhofer diffraction at single slit, double slit, and multiple slits; diffraction grating, characteristics of diffraction grating and its applications; Polarization: Introduction to polarization, polarisation by reflection, polarisation by double refraction, scattering of light, circular and elliptical polarisation, optical activity.

UNIT-II: Fibre Optics and LASERS (*12 lectures*)

Fibre Optics: Introduction, optical fibre as a dielectric wave guide: total internal reflection, numerical aperture and various fibre parameters, losses associated with optical fibres, step and graded index fibres, application of optical fibres; LASERS: Spontaneous and stimulated emission, Einstein's theory of matter radiation interaction and A and B coefficients; population inversion, pumping, various modes, properties of laser beams, types of lasers: gas lasers (He-Ne), solid-state lasers (ruby), applications.

PART-B

UNIT-III: Electromagnetism and Magnetic Properties of Materials ***(10 lectures)***

Laws of electrostatics: Coulomb and Gauss Law, electric current and the continuity equation, laws of magnetism: Ampere's and Faraday's laws. Maxwell's equations (derivation and physical significance), Dielectric polarisation, permeability and dielectric constant, polar and non-polar dielectrics, internal fields in a solid, Clausius-Mossotti equation, applications of dielectrics; Magnetisation, permeability and susceptibility, classification of magnetic materials, ferromagnetism, magnetic domains and hysteresis, applications.

Unit IV: Quantum Mechanics ***(10 lectures)***

Introduction to quantum physics, black body radiation, explanation using the photon concept, photoelectric effect, Compton effect, de Broglie hypothesis, wave-particle duality, Born's interpretation of the wave function, Davisson and Germer experiment: verification of matter waves, uncertainty principle, Schrodinger wave equation: particle in 1-dimensional box.

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. "Vibrations and waves in physics", I. G. Main, Cambridge University Press, 1993.
7. "The physics of vibrations and waves", H. J. Pain, Wiley, 2006.
8. "Optics", E. Hecht, Pearson Education, 2008.
9. "Optics", A. Ghatak, McGraw Hill Education, 2012.
10. "Principles of Lasers", O. Svelto, Springer Science & Business Media, 2010.
11. "Quantum mechanics", D. J. Griffiths, Pearson Education, 2014.
12. "Quantum Mechanics", R. Robinett, OUP Oxford, 2006.
13. "Semiconductor Physics and Devices", D.A. Neamen, Times Mirror High Education Group, Chicago, 1997.
14. "Microelectronic Devices", E.S. Yang, McGraw Hill, Singapore, 1988.
15. "Solid State Electronic Devices", B.G. Streetman, Prentice Hall of India, 1995.
16. HK Malik and AK Singh, Engineering Physics, 2nd ed., Tata McGraw Hill (2018).
17. https://nptel.ac.in/courses/117108037/3
18. https://nptel.ac.in/courses/115102023/

BTPH116-18	Optics and Electromagnetism Lab	L-0, T-0, P-3	1.5 Credits

Pre-requisite (if any): High-school education

Course Objectives: The aim and objective of the lab on Optics and Electromagnetism is to provide students the firsthand experience of verifying various theoretical concepts learnt in theory courses so that they can use these in their branch of Engineering as per their requirement.

Laboratory Outcomes: At the end of the course, students will be

CO1	Able to verify some of the theoretical concepts learnt in the theory courses.
CO2	Trained in carrying out precise measurements and handling sensitive equipment.
CO3	Introduced to 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	Write a technical report which communicates scientific information in a clear and concise manner.

Detailed Syllabus:

Note: Students are expected to perform about 10-12 experiments from the following list, selecting minimum of 7-8 from the Section-A and 3-4 from the Section-B.

Section-A

1. To study the magnetic field of a circular coil carrying current.
2. To find out polarizability of a dielectric substance.
3. To study the laser beam characteristics like; wave length using diffraction grating aperture & divergence.
4. To study laser interference using Michelson's Interferometer.
5. Study of diffraction using laser beam and thus to determine the grating element.
6. To determine numerical aperture of an optical fibre.
7. To determine attenuation & propagation losses in optical fibres.
8. To find out the frequency of AC mains using electric-vibrator.
9. To find the refractive index of a material using spectrometer.
10. To find the refractive index of a liquid using spectrometer.
11. To study B-H curve for a ferromagnetic material using CRO.
12. To find the velocity of ultrasound in liquid.
13. To determine the grain size of a material using optical microscope.
14. To study the characteristics of solar cell.
15. To study the Characteristics of Light Emitting Diode (LED).
16. To determine the energy gap of a given semi-conductor.
17. To determine the specific rotation of sugar using Laurent's half-shade polarimeter.

Section-B

Virtual lab:

1. To find the resolving power of the prism.
2. To determine the angle of the given prism.
3. To determine the refractive index of the material of a prism.
4. To find the numerical aperture of a given optic fibre and hence to find its acceptance angle.
5. To calculate the beam divergence and spot size of the given laser beam.
6. To determine the wavelength of a laser using the Michelson interferometer.
7. To revise the concept of interference of light waves in general and thin-film interference in particular.
8. To set up and observe Newton's rings.
9. To determine the wavelength of the given source.
10. To understand the phenomenon Photoelectric effect as a whole.
11. To draw kinetic energy of photoelectrons as a function of frequency of incident radiation.
12. To determine the Planck's constant from kinetic energy versus frequency graph.
13. To plot a graph connecting photocurrent and applied potential
14. To determine the stopping potential from the photocurrent versus applied potential graph.

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
12. http://vlab.amrita.edu/index.php?sub=1

BTPH107-18	**Introduction to Physics in Biotechnology**	**L-3, T-1, P-0**	**4 Credits**

Prerequisite (if any): High School knowledge

Course Objectives: The aim and objective of the course on Introduction to Physics in Biotechnology is to introduce the students of B. Tech. class to the basic concepts and applications of Lasers, fibre optics, X-rays, magnetic material, superconductivity and a brief introduction to quantum physics, so that they can use these in Engineering as per their requirement.

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

CO1	Identify and illustrate physical concepts and terminology used in Lasers, fibre optics and other wave phenomena.
CO2	Understand the X-Rays and their applications to the ultrasounds.
CO3	Understand the importance of wave equation in nature and appreciate the mathematical formulation of the same
CO4	Appreciate the need for quantum mechanics, wave particle duality, uncertainty principle etc.
CO5	Understand the properties of magnetic materials and superconductivity.

Detailed Syllabus:

PART-A

UNIT I: LASERS and Fibre Optics ***(10 lectures)***

Principles and working of laser: population inversion, pumping, threshold population inversion, types of laser: solid state (Ruby), gas (He-Ne); application of lasers (Medical/Industrial Applications); Fibre Optics: Introduction, optical fibre as a dielectric wave guide, total internal reflection, step and graded index fibres, numerical aperture and various fibre parameters, losses associated with optical fibres, application of optical fibres.

UNIT II: Magnetic Materials and Superconductivity ***(10 lectures)***

Origin of magnetism, Basic idea of Diamagnetic, Paramagnetic, Ferromagnetic, Ferrimagnetic and Ferrite materials, Soft and Hard Magnetic materials, magnetostriction, magnetic anisotropy, applications of magnetic materials; Superconductivity, properties of superconducting state, Meissner Effect, Type-I and Type-II superconductors, Introduction to BCS theory (Qualitative idea), applications in medical industry.

PART-B

UNIT III: X-rays and Ultrasounds ***(10 lectures)***

X-rays, Production of X-rays, Continuous and Characteristic X-Rays, Absorption of X-rays, Bragg's law, Adverse effects of X-rays, X-ray radiography; Ultrasounds: Ultra sound generators, properties of ultrasound-waves and its propagation in biological tissues, Pulse echo techniques, Doppler principle, involvement in design of medical instruments, Adverse effects of ultrasound waves.

UNIT IV: Quantum Theory and Nano-Materials (*(10 lectures)*

Photoelectric effect, Compton effect and de-Broglie waves; Wave-particle duality, concept of Electron microscopy; Nano-materials, surface to volume ratio, electron confinement (qualitative description), top-down and bottom-up method of synthesis, qualitative idea of quantum well, quantum wire and quantum dot. Carbon nanotubes: types, properties and applications.

Text and Reference Books:

1. Engineering Physics, Malik; HK, Singh; AK, Tata McGraw Hill.
2. Concepts of Modern Physics, Beiser; A., Tata McGraw Hill.
3. Introduction to Solids, Azaroff LV, Tata Mc Graw Hill.
4. Engineering Physics, D.K. Bhattacharya, Poonam Tondon, Oxford University Press.
5. Optical Fibre system, Technology, Design & Applications, Kao; CK, McGraw Hill.
6. Laser Theory & Applications, Thygrajan; K, Ghatak; AK, Mc Millan India Ltd.

BTPH117-18	**Physics lab**	**L-0, T-0, P-3**	**1.5 Credits**
Pre-requisite (if any): High-school education			
Course Objectives: The aim and objective of the Physics lab is to provide students the firsthand experience of verifying various theoretical concepts learnt in theory courses so that they can use these in Engineering as per their requirement.			
Laboratory Outcomes: At the end of the course, students will be			
CO1	Able to verify some of the theoretical concepts learnt in the theory courses.		
CO2	Trained in carrying out precise measurements and handling sensitive equipment.		
CO3	Introduced to 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	Write a technical report which communicates scientific information in a clear and concise manner.		

Detailed Syllabus:

Note: Students are expected to perform about 10-12 experiments from the following list, selecting minimum of 7-8 from the Section-A and 3-4 from the Section-B.

Section-A

1. To study the magnetic field of a circular coil carrying current.
2. To find out polarizability of a dielectric substance.
3. To study the laser beam characteristics like; wave length using diffraction grating aperture & divergence.
4. To study laser interference using Michelson's Interferometer.
5. Study of diffraction using laser beam and thus to determine the grating element.
6. To determine numerical aperture of an optical fibre.
7. To determine attenuation & propagation losses in optical fibres.
8. To find out the frequency of AC mains using electric-vibrator.
9. To determine the energy gap of a given semi-conductor.
10. To study B-H curve of a ferromagnetic material using CRO.
11. To find the velocity of ultrasound in liquid.
12. To determine the grain size of a material using optical microscope.
13. To study the characteristics of solar cell.
14. To study the Characteristics of Light Emitting Diode (LED).
15. To determine the specific rotation of sugar using Laurent's half-shade polarimeter.

Section-B

Virtual lab:

1. To find the numerical aperture of a given optic fibre and hence to find its acceptance angle.
2. To calculate the beam divergence and spot size of the given laser beam.
3. To determine the wavelength of a laser using the Michelson interferometer.
4. To revise the concept of interference of light waves in general and thin-film interference in particular.
5. To set up and observe Newton's rings.
6. To determine the wavelength of the given source.
7. To understand the phenomenon Photoelectric effect.
8. To draw kinetic energy of photoelectrons as a function of frequency of incident radiation.
9. To determine the Planck's constant from kinetic energy versus frequency graph.
10. To plot a graph connecting photocurrent and applied potential
11. To determine the stopping potential from the photocurrent versus applied potential graph.

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
12. http://vlab.amrita.edu/index.php?sub=1

Annexure VIII

Study Scheme & Syllabus of

Bachelor of Technology

(1st and 2nd semester)

Batch 2021 onwards

By

Department of Physical Sciences

IK Gujral Punjab Technical University

Sr. No.	Branch	Related Branches	Course codes	Course title	Credits
1	Civil Engineering	1. Civil Engineering 2.Construction Engineering & Management	BTPH101-21 BTPH111-21	Mechanics of solids Mechanics of solids Lab	4 1.5
2	Electrical Engineering	1.Electrical Engineering 2.Automation & Robotics 3.Electrical & Electronics Engineering 4.Electronics & Electrical Engineering 5.Electrical Engineering & Industrial Control 6.Instrumentation & Control Engineering	BTPH102-21 BTPH112-21	Optics and Modern Physics Optics and Modern Physics Lab	4 1.5
3	Mechanical Engineering	1.Mechanical Engineering 2.Marine Engineering 3.Production Engineering 4.Industrial Engineering 5.Tool Engineering 6.Automobile Engineering 7.Aerospace Engineering 8.Aeronautical Engineering	BTPH103-21 BTPH113-21	Electromagnetism Electromagnetism Lab	4 1.5
4	Computer Science Engineering	1.Computer Engineering 2.Computer Science Engineering 3.Information Technology 4.3D Animation Engineering	BTPH104-21 BTPH114-21	Semiconductor Physics Semiconductor Physics Lab	4 1.5

5	Electronics and communication Engineering	1.Electronics & Communication Engineering 2.Electronics & Computer Engineering 3.Electronics & Instrumentation Engineering 4.Electronics & Telecomm Engineering 5.Electronics Engineering	BTPH105-21 BTPH115-21	Semiconductor and Optoelectronics Physics Semiconductor and Optoelectronics Physics Lab	4 1.5
6	Chemical Sciences	1.Chemical Engineering 2.Petrochem & Petroleum Refinery Engineering 3.Textile Engineering 4.Food Technology	BTPH106-21 BTPH116-21	Optics and Electromagnetism Optics and Electromagnetism Lab	4 1.5
7	Bio-Technology	Bio-Technology	BTPH107-21 BTPH117-21	Introduction to Physics: Biotechnology Physics Lab	4 1.5

BTPH101-21	**Mechanics of Solids**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisites (if any): High-school education with Physics as one of the subject.			
Course Objectives: The aim and objective of the course on **Mechanics of Solids** is to introduce the students of B. Tech. 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.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Understand the vector mechanics for a classical system.		
CO2	Identify various types of forces in nature, frames of references, and conservation laws.		
CO3	Know the simple harmonic, damped, and forced simple harmonic oscillator for a mechanical system.		
CO4	Analyze the planar rigid body dynamics for a mechanical system.		
CO5	Apply the knowledge obtained in this course to the related problems.		

Detailed Syllabus:

PART-A

UNIT I: Vector mechanics ***(10 lectures)***

Introduction to Cartesian, spherical and cylindrical coordinate system; unit vectors, velocity, acceleration and line elements, Physical significance of gradient, Divergence and curl. Potential energy function, F = - Grad V, Newton's laws and its completeness in describing particle motion, Conservative and non-conservative forces, curl of a force field; Central forces; properties of space and time, Conservation of Angular Momentum and Energy, Inertial and Non-inertial frames of reference; Rotating coordinate system :- Centripetal and Coriolis force, accelerations, Forces in Nature.

UNIT II: Simple harmonic motion, damped and forced simple harmonic oscillator ***(10 lectures)***

Mechanical simple harmonic oscillators: simple pendulum, mass-string system in vertical and horizontal oscillations, damped oscillations, damped harmonic oscillator- heavy, critical and light damping, energy decay in a damped harmonic oscillator, logarithmic decrement, relaxation time, quality factor, forced mechanical oscillators, resonance.

PART-B

UNIT III: Planar rigid body mechanics ***(10 lectures)***

Definition and motion of a rigid body in plane; Rotation in the plane, Angular momentum about a point of a rigid body in planar motion; inertia tensor, center of mass, moment of inertia, theorems of moment of inertia, inertia of plane lamina, circular ring, moment of force, couple, Euler's laws of motion.

UNIT IV: Mechanics of solids ***(10 lectures)***

Friction: Definitions: Types of friction, Laws of static friction, Limiting friction, Angle of friction, angle of repose; motion on horizontal and inclined planes. Methods of reducing friction, Concept of stress and strain at a point; Concepts of elasticity, plasticity, strain hardening, failure (fracture/yielding), one dimensional stress-strain curve; Generalized Hooke's law. Force analysis — axial force, shear force, bending moment and twisting moment. Bending stress; Shear stress; Concept of strain energy; Yield criteria.

Reference books and suggested reading:

1. Engineering Mechanics, 2nd ed. - MK Harbola, Cengage Learning India, 2013.
2. Introduction to Mechanics - MK Verma, CRC Press Book, 2009.
3. Mechanics- DS Mathur, S Chand Publishing, 1981.
4. An Introduction to Mechanics - D Kleppner & R Kolenkow, Tata McGraw Hill 2009.
5. Principles of Mechanics - JL Synge & BA Griffiths, Nabu Press, 2011.
6. Mechanics - JP Den Hartog, Dover Publications Inc, 1961.
7. Engineering Mechanics- Dynamics, 7th ed. - JL Meriam, Wiley.
8. Theory of Vibrations with Applications -WT Thomson, Pearson.
9. An Introduction to the Mechanics of Solids, 2nd ed. with SI Units-SH Crandall, NC Dahl & TJ Lardner
10. Classical Mechanics- H. Goldstein, Pearson Education, Asia.
11. Classical mechanics of particles and rigid bodies - K.C Gupta, Wiley eastern, New Delhi.
12. Engineering Physics-Malik and Singh, Tata McGraw Hill.
13. Engineering Mechanics: Statics- 7th ed.-JL Meriam, Wiley, 2011.
14. Analytical Mechanics-Satish K Gupta, Modern Publishers.
15. https://nptel.ac.in/courses/122102004/

BTPH111-21	**Mechanics of Solids Lab**	**L-0, T-0, P-3**	**1.5 Credits**

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

Course Objectives: The aim and objective of the Lab course on **Mechanics of Solids** is to introduce the students of B. Tech to the formal structure of Mechanics of solids so that they can use these in Engineering as per their requirement.

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

CO1	Able to understand the concepts learned in the mechanics of solids.
CO2	Learning the skills needed to verify some of the concepts of theory courses.
CO3	Trained in carrying out precise measurements and handling sensitive equipment.
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.

Detailed Syllabus:

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, screw gauge, and travelling microscope. Use of Plumb line and Spirit level.
2. To find out the frequency of AC mains using electric-vibrator.
3. To determine the horizontal and vertical distance between two points using a Sextant.
4. To determine the height of an inaccessible object using a Sextant.
5. To determine the angular diameter of the sun using the sextant.
6. To determine the angular acceleration α, torque τ, and Moment of Inertia of flywheel.
7. To study the Motion of a Spring and calculate (a) Spring Constant (b) Value of **g** and (c) Modulus of rigidity.
8. To determine the time period of a simple pendulum for different lengths and acceleration due to gravity.
9. 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.
10. To determine the Young's Modulus of a Wire by Optical Lever Method.
11. To determine the Elastic Constants/Young's Modulus of a Wire by Searle's method.
12. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
13. To find the moment of inertia of an irregular body about an axis through its C.G with the torsional pendulum.
14. To determine **g** by Kater's Pendulum.
15. To determine **g** and velocity for a freely falling body using Digital Timing Technique.
16. Demonstration of collision behaviour for elastic and inelastic type and calculation of the Momentum, Kinetic energy, and Velocity after collision.

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. Laboratory Experiments in College Physics, C.H. Bernard and C.D. Epp, John Wiley and Sons, Inc., New York, 1995.
7. Practical Physics, G.L. Squires, Cambridge University Press, Cambridge, 1985.
8. Experiments in Modern Physics, A.C. Melissinos, Academic Press, N.Y., 1966.
9. Practical Physics, C L Arora. S. Chand & Company Ltd.
10. http://www.vlab.co.in

BTPH102-21	**Optics and Modern Physics**	**L-3, T-1, P-0**	**4 Credits**

Pre-requisite (if any):

1. High-school education with physics as one of the subject.
2. Mathematical course on differential equations.

Course Objectives: The aim and objective of the course on **Optics and Modern Physics** is to introduce the students of B.Tech. to the subjects of wave optics, Quantum Mechanics, Solids, and Semiconductors so that they can use these in Engineering as per their requirement.

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 wave phenomena.
CO2	Understand optical phenomenon, such as, interference, diffraction etc. in terms of wave model.
CO3	Understand the importance of wave equation in nature and appreciate the mathematical formulation of the same.
CO4	Appreciate the need for quantum mechanics, wave particle duality, uncertainty principle etc. and their applications.
CO5	Understand some of the basic concepts in the physics of solids and semiconductors.

Detailed Syllabus:

PART-A

UNIT I: Waves and Oscillations ***(10 lectures)***

Mechanical simple harmonic oscillators, damped harmonic oscillator, forced mechanical oscillators, impedance, steady state motion of forced damped harmonic oscillator, Transverse wave on a string, wave equation on a string, reflection and transmission of waves at a boundary, impedance matching, standing waves, longitudinal waves and their wave equation, reflection and transmission of waves at a boundary.

UNIT II: Optics and LASERS ***(10 lectures)***

Optics: Light as an electromagnetic wave, reflectance and transmittance, Fresnel equations (Qualitative idea), Brewster's angle, total internal reflection: Interference: Huygens' principle, superposition of waves and interference of light by wavefront splitting and amplitude splitting; Young's double slit experiment, Michelson interferometer. Diffraction: Farunhofer diffraction from a single slit and a circular aperture, Diffraction gratings and their resolving power; LASERS: Spontaneous and stimulated emission, Einstein's theory of matter radiation interaction and A and B coefficients; population inversion, pumping, various modes, properties of laser beams, types of lasers: gas lasers (He-Ne), solid-state lasers (ruby), and its applications.

PART-B

UNIT III: Introduction to Quantum Mechanics *(10 lectures)*

Wave nature of Particles, Free-particle wave function and wave-packets, probability densities, Expectation values, Uncertainty principle, Time-dependent and time-independent Schrodinger equation for wave function, Born interpretation, Solution of stationary-state Schrodinger equation for one dimensional problems: particle in a box, linear harmonic oscillator.

UNIT IV: Introduction to Solids and Semiconductors *(10 lectures)*

Free electron theory of metals, Fermi level, density of states in 1, 2 and 3 dimensions, Bloch's theorem for particles in a periodic potential, Origin of energy bands (Qualitative idea); Types of electronic materials: metals, semiconductors, and insulators, Intrinsic and extrinsic semiconductors, Dependence of Fermi level on carrier-concentration and temperature (equilibrium carrier statistics), Carrier generation and recombination, Carrier transport: diffusion and drift, p-n junction.

Reference books and suggested reading:

1. I. G. Main, "Vibrations and waves in physics", Cambridge University Press, 1993.
2. H. J. Pain, "The physics of vibrations and waves", Wiley, 2006.
3. E. Hecht, "Optics", Pearson Education, 2008.
4. A. Ghatak, "Optics", McGraw Hill Education, 2012.
5. O. Svelto, "Principles of Lasers", Springer Science & Business Media, 2010.
6. D. J. Griffiths, "Quantum mechanics", Pearson Education, 2014.
7. R. Robinett, "Quantum Mechanics", OUP Oxford, 2006.
8. D.A. Neamen, "Semiconductor Physics and Devices", Times Mirror High Education Group, Chicago, 1997.
9. E.S. Yang, "Microelectronic Devices", McGraw Hill, Singapore, 1988.
10. B.G. Streetman, "Solid State Electronic Devices", Prentice Hall of India, 1995.
11. HK Malik and AK Singh, Engineering Physics, 2nd ed., Tata McGraw Hill, 2018.
12. S. Sharma and J. Sharma, Engineering Physics, Pearson, 2018.
13. https://nptel.ac.in/courses/117108037/3
14. https://nptel.ac.in/courses/115102023/

BTPH112-21	**Optics and Modern Physics Lab**	**L-0, T-0, P-3**	**1.5 Credits**

Pre-requisite (If any): High-school education with physics as one of the subject.

Course Objectives: The aim and objective of the lab on **Optic and Modern Physics** is to introduce the students of B.Tech. class to the formal structure of wave and optics, Quantum Mechanics and semiconductor physics so that they can use these in Engineering branch as per their requirement.

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

CO1	Verify some of the theoretical concepts learnt in the theory courses.
CO2	Trained in carrying out precise measurements and handling sensitive equipment.
CO3	Introduced to 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	Write a technical report which communicates scientific information in a clear and concise manner.

Detailed Syllabus:

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. To study the laser beam characteristics like; wavelength using diffraction grating aperture & divergence.
2. To Study of diffraction using laser beam and thus to determine the grating element.
3. To study laser interference using Michelson's Interferometer.
4. To determine the numerical aperture of a given optic fibre and hence to find its acceptance angle.
5. To determine attenuation & propagation losses in optical fibres.
6. To determine the grain size of a material using optical microscope.
7. To find the refractive index of a material/glass/liquid using spectrometer.
8. To find the velocity of ultrasound in liquid.
9. To study the characteristic of different p-n junction diode - Ge and Si.
10. To analyze the suitability of a given Zener diode as voltage regulator.
11. To find out the intensity response of a solar cell/Photo diode/LED.
12. To find out the frequency of AC mains using electric-vibrator.
13. To find the resolving power and the angle of prism.
14. To determine the wavelength of the given source using Newton's rings method.
15. To understand the phenomenon Photoelectric effect and draw kinetic energy of photoelectrons as a function of frequency of incident radiation.
16. To determine the Planck's constant from kinetic energy versus frequency graph.
17. To determine the stopping potential from the photocurrent versus applied potential graph.

Reference books and suggested reading:

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. Laboratory Experiments in College Physics, C.H. Bernard and C.D. Epp, John Wiley and Sons, Inc., New York, 1995.
7. Practical Physics, G.L. Squires, Cambridge University Press, Cambridge, 1985.
8. Experiments in Modern Physics, A.C. Melissinos, Academic Press, N.Y., 1966.
9. Practical Physics, C L Arora. S. Chand & Company Ltd.
10. http://www.vlab.co.in

BTPH103-21	Electromagnetism	L-3, T-1, P-0	4 Credits

Pre-requisites (if any):

1. High-school education with physics as one of the subject.
2. Mathematical course on vector calculus.

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

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

CO1	Specify the constitutive relationships for fields and understand their important.
CO2	Describe the static and dynamic electric and magnetic fields for technologically important structures.
CO3	Measure the voltage induced by time varying magnetic flux.
CO4	acquire the knowledge of Maxwell equation and electromagnetic field theory and propagation and reception of electro-magnetic wave systems.
CO5	have a solid foundation in engineering fundamentals required to solve problems and also to pursue higher studies.

Detailed Syllabus:

PART-A

UNIT I: Electrostatics in vacuum and linear dielectric medium *(10 lectures)*

Calculation of electric field and electrostatic potential for a charge distribution; Divergence and curl of electrostatic field; Laplace's and Poisson's equations for electrostatic potential; Uniqueness theorem (Definition); examples: Faraday's cage; Boundary conditions of electric field; Energy of a charge distribution and its expression in terms of electric field. Electrostatic field and potential of a dipole. Bound charges due to electric polarization in Dielectrics; Electric displacement; Solving simple electrostatics problems in presence of dielectrics – Point charge at the centre of a dielectric sphere, charge in front of a dielectric slab.

UNIT II: Magnetostatics in linear magnetic medium *(10 lectures)*

Bio-Savart law, Divergence and curl of static magnetic field; Concept of vector potential, Magnetization and associated bound currents; auxiliary magnetic field $\vec{H}$; Boundary conditions on $\vec{B}$ and $\vec{H}$. Solving for magnetic field due to bar magnet; magnetic susceptibility and ferromagnetic, paramagnetic and diamagnetic materials; magnetic domains, hysteresis and B-H curve.

PART-B

UNIT III: Faraday's law and Maxwell's equations ***(10 lectures)***

Faraday's law; equivalence of Faraday's law and motional EMF; Lenz's law; Electromagnetic breaking and its applications; Differential form of Faraday's law; energy stored in a magnetic field. Continuity equation for current densities; Modifying equation for the curl of magnetic field to satisfy continuity equation; displacement current and magnetic field arising from time-dependent electric field; Maxwell's equation in vacuum and non-conducting medium; Flow of energy and Poynting vector and Poynting theorem.

UNIT IV: Electromagnetic waves ***(10 lectures)***

Wave equation for electromagnetic waves in free space and conducting medium, Uniform plane waves and general solution of uniform plane waves, relation between electric and magnetic fields of an electromagnetic wave their transverse nature.; Linear, circular and elliptical polarization, Reflection and transmission of electromagnetic waves from a non-conducting medium-vacuum interface for normal incidence.

Text and Reference Books:

1. D. Griffiths, Introduction to Electrodynamics, Pearson Education India; 4th ed. (2015).
2. J D Jackson, Classical Electrodynamics, John Wiley and Sons (1999).
3. Halliday and Resnick, Fundamentals of Physics, Wiley (2011).
4. W. Saslow, Electricity, Magnetism and Light, Academic Press (2002).
5. HK Malik and AK Singh, Engineering Physics, 2nd ed., Tata McGraw Hill (2018).

BTPH113-21	Electromagnetism Lab	L-0, T-0, P-3	1.5 Credits

Pre-requisite (If any): High-school education

Course Objectives: The aim and objective of the lab course on **Electromagnetism** is to introduce the students of B. Tech. class to the formal structure of electromagnetism so that they can use these in various branches of engineering as per their requirement.

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

CO1	Able to verify some of the theoretical concepts learnt in the 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	Write a technical report which communicates scientific information in a clear and concise manner.

Detailed Syllabus:

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 magnetic field of a circular coil carrying current.
3. To study B-H curve for a ferromagnetic material using CRO.
4. To find out the frequency of AC mains using electric-vibrator.
5. To find out polarizability of a dielectric substance.
6. Determine a high resistance by leakage method using Ballistic Galvanometer.
7. To study the characteristics of a Series RC Circuit.
8. To study the series LCR circuit and determine its (a) Resonant Frequency, (b) Quality.
9. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency (b) Quality factor Q.
10. To determine the value of self-inductance by Maxwell Inductance Bridge and Capacitance Bridge.
11. To determine the mutual inductance of two coils by Absolute method.
12. To study the induced emf as a function of the velocity of magnet and to study the phenomenon of electromagnetic damping.
13. To determine unknown capacitance by flashing and quenching method.
14. To study the field pattern of various modes inside a rectangular waveguide.
15. To determine charge to mass ratio (e/m) of an electron by helical method.
16. To determine charge to mass ratio (e/m) of an electron by Thomson method.
17. To find out the horizontal component of earth's magnetic field (B_h).

Reference books and suggested reading:

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. Laboratory Experiments in College Physics, C.H. Bernard and C.D. Epp, John Wiley and Sons, Inc., New York, 1995.
7. Practical Physics, G.L. Squires, Cambridge University Press, Cambridge, 1985.
8. Experiments in Modern Physics, A.C. Melissinos, Academic Press, N.Y., 1966.
9. Practical Physics, C L Arora, S. Chand & Company Ltd.
10. http://www.vlab.co.in

BTPH104-21	**Semiconductor Physics**	**L-3, T-1, P-0**	**4 Credits**

Prerequisite (if any): Introduction to Quantum Mechanics desirable

Course Objectives: The aim and objective of the course on **Semiconductor Physics** is to introduce the students of B. Tech. class to the formal structure of semiconductor physics so that they can use these in Engineering as per their requirement.

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

CO1	Understand and explain the fundamental principles and properties of electronic materials and semiconductors
CO2	Understand and describe the interaction of light with semiconductors in terms of fermi golden rule.
CO3	Understand and describe the impact of solid-state device capabilities and limitations on electronic circuit performance.
CO4	Understand the design, fabrication, and characterization techniques of Engineered semiconductor materials.
CO5	Develop the basic tools with which they can study and test the newly developed devices and other semiconductor applications.

Detailed Syllabus:

PART-A

UNIT 1: Electronic materials *(10 lectures)*

Free electron theory of metals, Density of states in 1D, 2D, and 3D, Bloch's theorem for particles in a periodic potential, Energy band diagrams, Kronig-Penny model (to introduce origin of band gap), Energy bands in solids, E-k diagram, Direct and indirect bandgaps, Types of electronic materials: metals, semiconductors, and insulators, Occupation probability, Fermi level, Effective mass.

UNIT II: Semiconductors *(10 lectures)*

Intrinsic and extrinsic semiconductors, Dependence of Fermi level on carrier-concentration and temperature (equilibrium carrier statistics), Carrier generation and recombination, Carrier transport: diffusion and drift, p-n junction, Metal-semiconductor junction (Ohmic and Schottky), Semiconductor materials of interest for optoelectronic devices.

PART-B

UNIT III: Light-semiconductor interaction *(10 lectures)*

Optical transitions in bulk semiconductors: absorption, spontaneous emission, and stimulated emission; Einstein coefficients, Population inversion, application in semiconductor Lasers; Joint density of states, Density of states for phonons, Transition rates (Fermi's golden rule), Optical loss and gain; Photovoltaic effect, Exciton, Drude model.

UNIT IV: Measurement Techniques ***(10 lectures)***

Measurement for divergence and wavelength using a semiconductor laser, Measurements for carrier density, resistivity, hall mobility using Four-point probe and van der Pauw method, Hot-point probe measurement, capacitance-voltage measurements, parameter extraction from diode I-V characteristics.

Reference books and suggested reading:

1. J. Singh: Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc. (1995).
2. B. E. A. Saleh and M. C. Teich: Fundamentals of Photonics, John Wiley & Sons, Inc., (2007).
3. S. M. Sze: Semiconductor Devices: Physics and Technology, Wiley (2008).
4. A. Yariv and P. Yeh, Photonics: Optical Electronics in Modern Communications, Oxford University Press, New York (2007).
5. P. Bhattacharya: Semiconductor Optoelectronic Devices, Prentice Hall of India (1997).
6. Ben G. Streetman: Solid State Electronics Devices, Pearson Prentice Hall.
7. D.A. Neamen, "Semiconductor Physics and Devices", Times Mirror High Education Group, Chicago, 1997.
8. E.S. Yang, "Microelectronic Devices", McGraw Hill, Singapore, 1988.
9. Online course: "Semiconductor Optoelectronics" by M R Shenoy on NPTEL.
10. Online course: "Optoelectronic Materials and Devices" by Monica Katiyar and Deepak Gupta on NPTEL.
11. Satayaparkash, 'Quantum Mechanics'.
12. A. Ghatak and Lokanathan, 'Quantum Mechanics'.

UNIT I Quantum Mechanics:

Need and origin of Quantum Concept, Wave-particle duality, Matter waves, Group and Phase velocities, Concept of Uncertainty Principle and its application: nonexistence of electron in the nucleus, Born interpretation of wave function & its significance, normalization of wave function, Schrodinger wave equation: time independent and dependent, Eigen functions & Eigen values, particle in a box in 1-D. Concept of scattering from a potential barrier and tunneling.

UNIT-II Electronic Materials: (8 Hrs.)

Free electron theory, Density of states and energy band diagrams, Introduction to band gap theory, Direct and indirect band gaps. Types of electronic materials: metals, semiconductors and insulators, Occupation probability, Fermi level, Effective mass, phonons.

UNIT-III Semiconductors and Light- Semiconductor Interactions: (12 Hrs.)

Intrinsic and extrinsic semiconductors, Dependence of Fermi level on carrier-concentration and temperature (equilibrium carrier statistics), Carrier generation and recombination, Carrier transport: diffusion and drift, p-n junction, Metal-semiconductor junction (Ohmic and Schottky), Semiconductor materials of interest for optoelectronic devices. Optical transitions in bulk semiconductors: absorption, spontaneous emission, and stimulated emission;

Lasers: principles and working of laser: population inversion, pumping, types of lasers with emphasis on the semi-conductor Lasers.

UNIT-IV Fibre Optics Communication: (8 Hrs.)

Introduction and importance of use of optical fibres in data transmission, optical fibre as a dielectric wave guide: total internal reflection, numerical aperture and various fibre parameters, losses associated with optical fibres, step and graded index fibres, applications of optical fibres.

BTPH114-21	Semiconductor Physics Lab	L-0, T-0, P-3	1.5 Credits

Pre-requisite (if any): (i) High-school education

Course Objectives: The aim and objective of the Lab course on **Semiconductor Physics** is to introduce the students of B.Tech. class to the formal structure of semiconductor physics so that they can use these in Engineering as per their requirement.

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

CO1	Able to verify some of the theoretical concepts learnt in the theory courses.
CO2	Trained in carrying out precise measurements and handling sensitive equipment.
CO3	Introduced to 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	Write a technical report which communicates scientific information in a clear and concise manner.

Detailed Syllabus:

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. To study the characteristic of different PN junction diode-Ge and Si.
2. To analyze the suitability of a given Zener diode as a power regulator.
3. To find out the intensity response of a solar cell/Photo diode/LED.
4. To determine the band gap and resistivity of a semiconductor by four probe method.
5. To study voltage regulation and ripple factor for a half-wave and a full-wave rectifier without and with different filters.
6. To study the magnetic field of a circular coil carrying current.
7. To find out polarizability of a dielectric substance.
8. To study B-H curve of a ferro-magnetic material using CRO.
9. To find out the frequency of AC mains using electric-vibrator.
10. To find the velocity of ultrasound in liquid.
11. To study the Hall effect for the determination of charge current densities.
12. Distinguish between Diamagnetic material, Paramagnetic and ferromagnetic material.
13. Measurement of susceptibility of a liquid or a solution by Quincke's method.
14. To study the sample with the nano-scale objects and measure surface topography with different scales, width and height of nano objects, and force-distance curves using AFM.
15. To study the temperature coefficient of Resistance of copper.
16. To compare various capacitance and verify the law of addition of capacitance.
17. Verification of the curie Weiss law for the electrical susceptibility of a ferromagnetic material.
18. To study the laser beam characteristics like; wave length using diffraction grating aperture & divergence.
19. To study laser interference using Michelson's Interferometer.
20. Study of diffraction using laser beam and thus to determine the grating element.
21. Verification and design of combinational logic using AND, OR, NOT, NAND and XOR gates.

Reference books and suggested reading:

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. Laboratory Experiments in College Physics, C.H. Bernard and C.D. Epp, John Wiley and Sons, Inc., New York, 1995.
7. Practical Physics, G.L. Squires, Cambridge University Press, Cambridge, 1985.
8. Experiments in Modern Physics, A.C. Melissinos, Academic Press, N.Y., 1966.
9. Practical Physics, C L Arora, S. Chand & Company Ltd.
10. http://www.vlab.co.in

BTPH105-21	**Semiconductor and Optoelectronics Physics**	**L-3, T-1, P-0**	**4 Credits**

Prerequisite (if any): "Introduction to Quantum Mechanics" Desirable

Course Objectives: The aim and objective of the course on **Semiconductor and Optoelectronics Physics** is to introduce the students of B. Tech. class to the formal structure of semiconductor physics and Optoelectronics so that they can use these in Engineering as per their requirement.

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

CO1	Understand and explain the fundamental principles and properties of electronic materials and semiconductors.
CO2	Understand and describe the interaction of light with semiconductors in terms of fermi golden rule.
CO3	Understand and describe the impact of solid-state device capabilities and limitations on electronic circuit performance.
CO4	Understand the design, fabrication, characterization techniques, and measurements of Engineered semiconductor materials.
CO5	Learn the basics of the optoelectronic devices, LEDs, semiconductor lasers, and photo detectors.

Detailed Syllabus:

PART-A

UNIT -I: Electronic materials ***(10 lectures)***

Free electron theory of metals, Density of states in 1D, 2D, and 3D, Bloch's theorem for particles in a periodic potential, energy band diagrams, Kronig-Penny model (to introduce origin of band gap), Energy bands in solids, E-k diagram, Direct and indirect band gaps, Types of electronic materials: metals, semiconductors and insulators, Occupation probability, Fermi level, Effective mass of electron and hole.

UNIT -II: Semiconductors ***(10 lectures)***

Intrinsic and extrinsic semiconductors, Dependence of Fermi level on carrier-concentration and temperature (equilibrium carrier statistics), Carrier generation and recombination, Carrier transport: diffusion and drift, p-n junction, Metal-semiconductor junction (Ohmic and Schottky).

PART-B

UNIT -III: Optoelectronic devices ***(10 lectures)***

Radiative and non-radiative recombination mechanisms in semiconductors, Semiconductor materials of interest for optoelectronic devices; Semiconductor light emitting diodes (LEDs): light emitting materials, device structure, characteristics; Optical transitions in bulk semiconductors: absorption, spontaneous emission, and stimulated emission, Semiconductor laser: population inversion at a junction, structure, materials, device characteristics, Photovoltaics: Types of semiconductor photo detectors-p-n junction, PIN, and Avalanche-and their structure, materials, working principle, and characteristics, Noise limits on performance.

UNIT-IV: Measurement techniques ***(10 lectures)***

Measurement for divergence and wavelength using a semiconductor laser, Measurements for carrier density, resistivity, and hall mobility using Four-point probe and van der Pauw method, Hot-point probe measurement, capacitance-voltage measurements, parameter extraction from diode I-V characteristics.

Reference books and suggested reading:

1. J. Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc. (1995).
2. B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc. (2007).
3. S. M. Sze, Semiconductor Devices: Physics and Technology, Wiley (2008).
4. A. Yariv and P. Yeh, Photonics: Optical Electronics in Modern Communications, Oxford University Press, New York (2007).
5. P. Bhattacharya: Semiconductor Optoelectronic Devices, Prentice Hall of India (1997).
6. Solid state electronics devices: Ben. G. Streetman Pearson Prentice Hall.
7. D.A. Neamen: “Semiconductor Physics and Devices”, Times Mirror High Education Group, Chicago, 1997.
8. E.S. Yang: “Microelectronic Devices”, McGraw Hill, Singapore, 1988.
9. Online course: “Semiconductor Optoelectronics” by M R Shenoy on NPTEL.
10. Online course: "Optoelectronic Materials and Devices" by Monica Katiyar and Deepak Gupta on NPTEL.

BTPH115-21	Semiconductor and Optoelectronics Physics Lab	L-0, T-0, P-3	1.5 Credits

Pre-requisite (if any): High-school education

Course Objectives: The aim and objective of the Lab course on **Semiconductor and Optoelectronics Physics** is to introduce the students of B.Tech. class to the formal lab structure of semiconductor physics so that they can use these in Engineering as per their requirement.

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

CO1	Able to verify some of the theoretical concepts learnt in the theory courses.
CO2	Trained in carrying out precise measurements and handling sensitive equipment.
CO3	Introduced to 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	Write a technical report which communicates scientific information in a clear and concise manner.

Detailed Syllabus:

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. To study the characteristic of different PN junction diode-Ge and Si.
2. To analyze the suitability of a given Zener diode as a power regulator.
3. To find out the intensity response of a solar cell/Photo diode.
4. To find out the intensity response of a LED.
5. To determine the band gap of a semiconductor.
6. To determine the resistivity of a semiconductor by four probe method.
7. To confirm the de Broglie equation for electrons.
8. To study voltage regulation and ripple factor for a half-wave and a full-wave rectifier without and with different filters.
9. To study the magnetic field of a circular coil carrying current.
10. To find out polarizability of a dielectric substance.
11. To study B-H curve of a ferro-magnetic material using CRO.
12. To find out the frequency of AC mains using electric-vibrator.
13. To find the velocity of ultrasound in liquid.
14. To study the Hall effect for the determination of charge current densities.
15. Distinguish between diamagnetic material, paramagnetic and ferromagnetic material.
16. Measurement of susceptibility of a liquid or a solution by Quincke's method.
17. To study the sample with the nano-scale objects and measure surface topography with different scales, width and height of nano objects, and force-distance curves using AFM.
18. To study the temperature coefficient of Resistance of copper.
19. To determine the ratio k/e using a transistor.
20. To compare various capacitance and verify the law of addition of capacitance.
21. To measure the temperature dependence of a ceramic capacitor.
22. Verification of the curie Weiss law for the electrical susceptibility of a ferromagnetic material.
23. To study the laser beam characteristics like; wave length using diffraction grating aperture & divergence.

24. To study laser interference using Michelson's Interferometer.
25. Study of diffraction using laser beam and thus to determine the grating element.

Section-B

Virtual lab:

1. To draw the static current-voltage (I-V) characteristics of a junction diode.
2. To plot the characteristics of thermistor and hence find the temperature coefficient of resistance.
3. To determine the resistivity of semiconductors by Four Probe Method.
4. To study Zener diode voltage as regulator and measure its line and load regulation.
5. To study the B-H Curve for a ferromagnetic material.
6. To study the Hall effect experiment to determine the charge carrier density.
7. To determine the magnetic susceptibilities of paramagnetic liquids by Quincke's Method.
8. To study the phenomena of magnetic hysteresis and calculate the retentivity, coercivity and saturation magnetization of a material using a hysteresis loop tracer.
9. Verification and design of combinational logic using AND, OR, NOT, NAND and XOR gates.

Reference books and suggested reading:

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. Laboratory Experiments in College Physics, C.H. Bernard and C.D. Epp, John Wiley and Sons, Inc., New York, 1995.
7. Practical Physics, G.L. Squires, Cambridge University Press, Cambridge, 1985.
8. Experiments in Modern Physics, A.C. Melissinos, Academic Press, N.Y., 1966.
9. Practical Physics, C L Arora, S. Chand & Company LTD.
10. http://www.vlab.co.in

BTPH106-21	Optics and Electromagnetism	L-3, T-1, P-0	4 Credits

Prerequisite (if any): Introduction to Quantum Mechanics desirable

Course Objectives: The aim and objective of the course on **Optics and Electromagnetism** is to introduce the students of B.Tech. class to the basic concepts of optics and its applications, electricity and magnetism, and quantum physics, so that they can use these in Engineering as per their requirement.

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

CO1	Identify and illustrate physical concepts and terminology used in optics and other wave phenomena.
CO2	Understand optical phenomena such as polarization, birefringence, interference, and diffraction in terms of the wave model.
CO3	Understand the importance of wave equation in nature and appreciate the mathematical formulation of the same
CO4	Acquire knowledge about the Maxwell equation and magnetic properties of materials.
CO5	Appreciate the need for quantum mechanics, wave particle duality, uncertainty principle etc.

Detailed syllabus:

PART-A

Unit I: Wave Optics (*8 lectures*)

Diffraction: Introduction to interference and example; concept of diffraction, Fraunhofer and Fresnel diffraction, Fraunhofer diffraction at single slit, double slit, and multiple slits; diffraction grating, characteristics of diffraction grating and its applications; Polarization: Introduction to polarization, polarisation by reflection, polarisation by double refraction, scattering of light, circular and elliptical polarisation, optical activity.

UNIT-II: Fibre Optics and LASERS (*12 lectures*)

Fibre Optics: Introduction, optical fibre as a dielectric wave guide: total internal reflection, numerical aperture and various fibre parameters, losses associated with optical fibres, step and graded index fibres, application of optical fibres; LASERS: Spontaneous and stimulated emission, Einstein's theory of matter radiation interaction and A and B coefficients; population inversion, pumping, various modes, properties of laser beams, types of lasers: gas lasers (He-Ne), solid-state lasers (ruby), applications.

PART-B

UNIT-III: Electromagnetism and Magnetic Properties of Materials ***(10 lectures)***

Laws of electrostatics: Coulomb and Gauss Law, electric current and the continuity equation, laws of magnetism: Ampere's and Faraday's laws. Maxwell's equations (derivation and physical significance), Dielectric polarisation, permeability and dielectric constant, polar and non-polar dielectrics, internal fields in a solid, Clausius-Mossotti equation, applications of dielectrics; Magnetisation, permeability and susceptibility, classification of magnetic materials, ferromagnetism, magnetic domains and hysteresis, applications.

Unit IV: Quantum Mechanics ***(10 lectures)***

Introduction to quantum physics, black body radiation, explanation using the photon concept, photoelectric effect, Compton effect, de Broglie hypothesis, wave-particle duality, Born's interpretation of the wave function, Davisson and Germer experiment: verification of matter waves, uncertainty principle, Schrodinger wave equation: particle in 1-dimensional box.

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. "Vibrations and waves in physics", I. G. Main, Cambridge University Press, 1993.
7. "The physics of vibrations and waves", H. J. Pain, Wiley, 2006.
8. "Optics", E. Hecht, Pearson Education, 2008.
9. "Optics", A. Ghatak, McGraw Hill Education, 2012.
10. "Principles of Lasers", O. Svelto, Springer Science & Business Media, 2010.
11. "Quantum mechanics", D. J. Griffiths, Pearson Education, 2014.
12. "Quantum Mechanics", R. Robinett, OUP Oxford, 2006.
13. "Semiconductor Physics and Devices", D.A. Neamen, Times Mirror High Education Group, Chicago, 1997.
14. "Microelectronic Devices", E.S. Yang, McGraw Hill, Singapore, 1988.
15. "Solid State Electronic Devices", B.G. Streetman, Prentice Hall of India, 1995.
16. HK Malik and AK Singh, Engineering Physics, 2nd ed., Tata McGraw Hill (2018).
17. https://nptel.ac.in/courses/117108037/3
18. https://nptel.ac.in/courses/115102023/

BTPH116-21	Optics and Electromagnetism Lab	L-0, T-0, P-3	1.5 Credits

Pre-requisite (if any): High-school education

Course Objectives: The aim and objective of the lab on Optics and Electromagnetism is to provide students the firsthand experience of verifying various theoretical concepts learnt in theory courses so that they can use these in their branch of Engineering as per their requirement.

Laboratory Outcomes: At the end of the course, students will be

CO1	Able to verify some of the theoretical concepts learnt in the theory courses.
CO2	Trained in carrying out precise measurements and handling sensitive equipment.
CO3	Introduced to 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	Write a technical report which communicates scientific information in a clear and concise manner.

Detailed Syllabus:

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. To study the magnetic field of a circular coil carrying current.
2. To find out polarizability of a dielectric substance.
3. To study the laser beam characteristics like; wave length using diffraction grating aperture & divergence.
4. To study laser interference using Michelson's Interferometer.
5. Study of diffraction using laser beam and thus to determine the grating element.
6. To determine numerical aperture of an optical fibre.
7. To determine attenuation & propagation losses in optical fibres.
8. To find out the frequency of AC mains using electric-vibrator.
9. To find the refractive index of a material using spectrometer.
10. To find the refractive index of a liquid using spectrometer.
11. To study B-H curve for a ferromagnetic material using CRO.
12. To find the velocity of ultrasound in liquid.
13. To determine the grain size of a material using optical microscope.
14. To study the characteristics of solar cell.
15. To study the Characteristics of Light Emitting Diode (LED).
16. To determine the energy gap of a given semi-conductor.
17. To determine the specific rotation of sugar using Laurent's half-shade polarimeter.

Section-B

Virtual lab:

1. To find the resolving power of the prism.
2. To determine the angle of the given prism.
3. To determine the refractive index of the material of a prism.
4. To find the numerical aperture of a given optic fibre and hence to find its acceptance angle.
5. To calculate the beam divergence and spot size of the given laser beam.
6. To determine the wavelength of a laser using the Michelson interferometer.
7. To revise the concept of interference of light waves in general and thin-film interference in particular.
8. To set up and observe Newton's rings.
9. To determine the wavelength of the given source.
10. To understand the phenomenon Photoelectric effect as a whole.
11. To draw kinetic energy of photoelectrons as a function of frequency of incident radiation.
12. To determine the Planck's constant from kinetic energy versus frequency graph.
13. To plot a graph connecting photocurrent and applied potential
14. To determine the stopping potential from the photocurrent versus applied potential graph.

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
12. http://vlab.amrita.edu/index.php?sub=1

BTPH107-21	Introduction to Physics in Biotechnology	L-3, T-1, P-0	4 Credits
Prerequisite (if any): High School knowledge			
Course Objectives: The aim and objective of the course on Introduction to Physics in Biotechnology is to introduce the students of B. Tech. class to the basic concepts and applications of Lasers, fibre optics, X-rays, magnetic material, superconductivity and a brief introduction to quantum physics, so that they can use these in Engineering as per their requirement.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Identify and illustrate physical concepts and terminology used in Lasers, fibre optics and other wave phenomena.		
CO2	Understand the X-Rays and their applications to the ultrasounds.		
CO3	Understand the importance of wave equation in nature and appreciate the mathematical formulation of the same		
CO4	Appreciate the need for quantum mechanics, wave particle duality, uncertainty principle etc.		
CO5	Understand the properties of magnetic materials and superconductivity.		

Detailed Syllabus:

PART-A

UNIT I: LASERS and Fibre Optics ***(10 lectures)***

Principles and working of laser: population inversion, pumping, threshold population inversion, types of laser: solid state (Ruby), gas (He-Ne); application of lasers (Medical/Industrial Applications); Fibre Optics: Introduction, optical fibre as a dielectric wave guide, total internal reflection, step and graded index fibres, numerical aperture and various fibre parameters, losses associated with optical fibres, application of optical fibres.

UNIT II: Magnetic Materials and Superconductivity ***(10 lectures)***

Origin of magnetism, Basic idea of Diamagnetic, Paramagnetic, Ferromagnetic, Ferrimagnetic and Ferrite materials, Soft and Hard Magnetic materials, magnetostriction, magnetic anisotropy, applications of magnetic materials; Superconductivity, properties of superconducting state, Meissner Effect, Type-I and Type-II superconductors, Introduction to BCS theory (Qualitative idea), applications in medical industry.

PART-B

UNIT III: X-rays and Ultrasounds ***(10 lectures)***

X-rays, Production of X-rays, Continuous and Characteristic X-Rays, Absorption of X-rays, Bragg's law, Adverse effects of X-rays, X-ray radiography; Ultrasounds: Ultra sound generators, properties of ultrasound-waves and its propagation in biological tissues, Pulse echo techniques, Doppler principle, involvement in design of medical instruments, Adverse effects of ultrasound waves.

UNIT IV: Quantum Theory and Nano-Materials (*(10 lectures)*

Photoelectric effect, Compton effect and de-Broglie waves; Wave-particle duality, concept of Electron microscopy; Nano-materials, surface to volume ratio, electron confinement (qualitative description), top-down and bottom-up method of synthesis, qualitative idea of quantum well, quantum wire and quantum dot. Carbon nanotubes: types, properties and applications.

Text and Reference Books:

1. Engineering Physics, Malik; HK, Singh; AK, Tata McGraw Hill.
2. Concepts of Modern Physics, Beiser; A., Tata McGraw Hill.
3. Introduction to Solids, Azaroff LV, Tata Mc Graw Hill.
4. Engineering Physics, D.K. Bhattacharya, Poonam Tondon, Oxford University Press.
5. Optical Fibre system, Technology, Design & Applications, Kao; CK, McGraw Hill.
6. Laser Theory & Applications, Thygrajan; K, Ghatak; AK, Mc Millan India Ltd.

BTPH117-21	**Physics lab**	**L-0, T-0, P-3**	**1.5 Credits**

Pre-requisite (if any): High-school education

Course Objectives: The aim and objective of the Physics lab is to provide students the firsthand experience of verifying various theoretical concepts learnt in theory courses so that they can use these in Engineering as per their requirement.

Laboratory Outcomes: At the end of the course, students will be

CO1	Able to verify some of the theoretical concepts learnt in the theory courses.
CO2	Trained in carrying out precise measurements and handling sensitive equipment.
CO3	Introduced to 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	Write a technical report which communicates scientific information in a clear and concise manner.

Detailed Syllabus:

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. To study the magnetic field of a circular coil carrying current.
2. To find out polarizability of a dielectric substance.
3. To study the laser beam characteristics like; wave length using diffraction grating aperture & divergence.
4. To study laser interference using Michelson's Interferometer.
5. Study of diffraction using laser beam and thus to determine the grating element.
6. To determine numerical aperture of an optical fibre.
7. To determine attenuation & propagation losses in optical fibres.
8. To find out the frequency of AC mains using electric-vibrator.
9. To determine the energy gap of a given semi-conductor.
10. To study B-H curve of a ferromagnetic material using CRO.
11. To find the velocity of ultrasound in liquid.
12. To determine the grain size of a material using optical microscope.
13. To study the characteristics of solar cell.
14. To study the Characteristics of Light Emitting Diode (LED).
15. To determine the specific rotation of sugar using Laurent's half-shade polarimeter.

Section-B

Virtual lab:

1. To find the numerical aperture of a given optic fibre and hence to find its acceptance angle.
2. To calculate the beam divergence and spot size of the given laser beam.
3. To determine the wavelength of a laser using the Michelson interferometer.
4. To revise the concept of interference of light waves in general and thin-film interference in particular.
5. To set up and observe Newton's rings.
6. To determine the wavelength of the given source.
7. To understand the phenomenon Photoelectric effect.
8. To draw kinetic energy of photoelectrons as a function of frequency of incident radiation.
9. To determine the Planck's constant from kinetic energy versus frequency graph.
10. To plot a graph connecting photocurrent and applied potential
11. To determine the stopping potential from the photocurrent versus applied potential graph.

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
12. http://vlab.amrita.edu/index.php?sub=1

GOVERNMENT OF PUNJAB
DEPARTMENT OF TECHNICAL EDUCATION AND INDUSTRIAL TRAINING
(TECHNICAL EDUCATION BRANCH - II)

NOTIFICATION

No. TECH-TE-2013/4/2021-4TE2/ 1/229119/2021 Dated: 13/08/2021

1.0 The Governor of Punjab is pleased to appoint the I. K. Gujral Punjab Technical University, Kapurthala as the authority competent to conduct the Online Centralized Counselling for admission to various degree levels Engineering Courses being run in the Institutions and Universities located in the State of Punjab on the basis of JEE (Main) for the Academic Session 2021-22. The admission shall be made in the colleges affiliated to Universities/Campuses of the Universities mentioned below:-

1. I. K. Gujral Punjab Technical University, Kapurthala
2. Maharaja Ranjit Singh Punjab Technical University, Bathinda
3. Punjab Agricultural University, Ludhiana

Note: The name of colleges, branches in each college and the number of seats will be as given in the letter of approval issued by AICTE/Concerned University (in case of University Campuses / Constituent Campuses only) for the year 2021-22.

As per All India Council for Technical Education, New Delhi letter No. AICTE/Adv-I/AB/2016/86 dated 08.12.2016 and letter dated 07-07-2020:-

(i) In no eventually, a Technical Institution without prior approval of the AICTE, and affiliating University shall be allowed to participate in the counselling and admission process and to admit students. Affiliating University shall not enroll students admitted in such Technical Institutions, which do not have requisite approval of the AICTE.

(ii) University shall not grant affiliation to a Technical Institution approved by AICTE after the last date as issued by AICTE in the Calendar Year in which the academic session is to commence.

(iii) Affiliating University shall not permit any Technical Institution to admit students without requisite prior approval of the AICTE.

(iv) University/Institution shall not permit admissions of students to Technical Program which are not approved by the AICTE.

2.0 The Governor of Punjab is also pleased to further issue the following criteria for making admissions:-

A. Eligibility Criteria (Educational Qualifications and Resident Status) for admission

(i) For admission to the Engineering Courses, 85% seats shall be open for the candidates from within the State and 15% will be open for the candidates from outside the State.

(ii) Admission shall be made on the basis of rank of JEE (Main) for both 85% quota for residents of Punjab and 15% quota for outside Punjab.

a) For Engineering & Technology Courses

(i) 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.

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.

(ii) The candidates whose results are not declared/pending (due to whatsoever reason) in the qualifying examination, shall also be eligible to appear for counseling on the basis of JEE (Main) merit. The admission of such candidates shall be purely provisional and shall stand cancelled, if they fail to produce their eligibility at the time of admission and such candidates shall have no claim, whatsoever, for admission to these courses through Counseling.

Eligibility for PAU, Ludhiana

(i) In addition to conditions enumerated above for admission to Engineering courses run by Punjab Agricultural University, Ludhiana, the eligibility criteria of the concerned university, shall be applicable.

(ii) In case of any dispute, decision of the competent authority conducting the counselling shall be final and binding on all.

B. <u>GENERAL ELIGIBILITY CRITERIA FOR ADMISSION TO DEGREE LEVEL ENGINEERING AND TECHNOLOGY COURSES:</u>

Apart from the basic educational qualifications prescribed above, the general eligibility criteria shall be as contained in Punjab Government, Department of Technical Education & Industrial Training, Punjab Memo No. 35/44/95-1T(2)/978 dated 21st March, 2003, which is attached as Annexure. This communication shall be treated as a part and parcel of this notification, for all purposes, and all the provisions of this notification shall be read along with the contents of the said communication.

<u>Exemption under above Para</u>

Children/wards/dependent (whose parent are not alive) of all those regular Punjab Government employees, members of All India Service borne on Punjab cadre, Serving judges and the employees of the Punjab and Haryana High Court, employees of Boards/ Corporations/Statutory Bodies established by an act of the state of Punjab who have been holding post outside Punjab on or before 1st January of the year of entrance test that is on or before 1st January, 2021 and their children/wards/ dependents may have done 10+1 and/or 10+2 outside Punjab.

C. <u>RESERVATION:</u>

(i) The reservation of seats shall be as per Punjab Government, Department of Technical Education and Industrial Training Memo. No. 13 / 2/ 05 -1TE2/1987 dated 2nd July, 2013 and memo no. 8/41/2019-4TE2/53 dated 13.09.2019, which are attached as Annexures. This communication shall be treated as a part and parcel of this notification, for all purposes, and all the provisions of these notifications shall be read along with the contents of the said communication.

(ii) The attention of the applicants desirous of claiming reservation under any category whatsoever is especially drawn to the condition and stipulation that only the certificates that have been produced at the time of admission shall be considered. The candidates are accordingly advised, in their own interest, to get the requisite certificates issued well before the date of admission, otherwise, claim for reservation shall be summarily rejected.

Candidates are required to claim reservation at the time of registering for online Centralized Counselling. If no reservation is claimed the candidates shall be treated and considered as a "General Candidate".

(iii) The I. K. Gujral Punjab Technical University shall make a provision in the application form for a candidate to indicate the category, if any, under which he/she is seeking reservation. There shall also be a provision to indicate the sub-category of the category, if any, under which reservation is being sought, so that *inter se* gradation can be facilitated. These sub-categories have been elucidated in the Punjab Government, Department of Technical Education and Industrial Training Memo. No. 13 / 2/ 05 -1TE2/1987 dated 2nd July, 2013 and memo no. 8/41/2019-4TE2/53 dated 13.09.2019, which are attached as Annexures. Punjab Government may also set up a committee to effect *inter se* gradation of candidates claiming reservation under certain categories, as indicated in the aforesaid memos dated 2nd July, 2013 and 13.09.2019.

(iv) A candidate shall be eligible to make a claim for reservation in any of the reserved category. However, the procedure for a counselling shall be as per Punjab Government, Welfare Department (Reservation Cell) Memo. No. 7/21/2004 - RS1 / 1674 - 1677 dated 20th Dec., 2004.

D. GENERAL CONDITIONS:

(i) There shall be Centralized Counselling by I. K. Gujral Punjab Technical University. The procedure for Centralized Counselling shall be decided by the I. K. Gujral Punjab Technical University. However, the following category of seats shall be filled through direct Counselling other than Centralized Counseling:

Sub categories, Priority for making admission under Defence Category, Para-Military and TA/RA Category & ICAR Nomination seats, Disabled Person Category of PAU, Ludhiana.

For the above categories, counselling shall be done by I. K. Gujral Punjab Technical University, Kapurthala, whereas for other categories, counselling shall be done by the concerned Universities/Institutions, but the nominee of I. K. Gujral Punjab Technical University, Kapurthala, shall be associated for these counselling. However, Guru Nanak Dev Engineering College, Ludhiana will itself admit candidates under Rural Quota (Except for SC Candidates) of B.Tech. First Year through counselling on the basis of merit criterion as per seat matrix before the start of online counseling by the I. K. Gujral Punjab Technical University, Kapurthala.

(ii) The students shall be liable to pay Fee / Development Fee and other charges as per the rates of Fee / Development Fee and other charges to the concerned college as fixed by the Government of Punjab/AICTE/Concerned University, from time to time.

(iii) The management quota shall be as per Punjab Govt., Department of Technical Education and Industrial Training Memo no. 13/129/2003-1TE2/1247 dated 25th April 2008 and Partial notification no. 13/129/2003-1TE2/1892 dated 20th June 2008 and partial notification no. 13/129/2003-1TE2/171 dated 18th January, 2011 which are attached as Annexures.

(iv) Appearing in JEE (Main) shall be compulsory for students claiming seats under 85% quota reserved for Punjab residents and also to students claiming seats under 15% quota reserved for those outside Punjab i.e. All India. If a candidate is not able to produce his residence certificate, he / she shall be considered for 15% quota only.

(v) Admissions to the Engineering courses, both for 85% seats for resident of Punjab and 15% seats for outsiders shall be made strictly on the basis of JEE (Main). Incase seats are not being filled under respective categories, admission may be considered on inter-se-merit of marks obtained in qualifying examination.

(vi) Counselling for 85% seats for Punjab residents and 15% outside Punjab candidates shall be taken up simultaneously. However, the reserved category candidates shall be considered in general category first before being considered in respective reserved category.

(vii) The College / University will issue a public notice on official website to this effect indicating clearly the number of seats vacant in each reserve category and general category and fill the seats in that very particular category in all the rounds of counselling.

(viii) After following the above said procedure, if still the seats remain vacant in reserve category, the college / university can fill these from candidates belonging to general category in a subsequent step at the end of Centralized Counseling. Admission to such unfilled/vacant seats as well as management quota shall be furnished to theI. K. Gujral Punjab Technical University and details thereof shall be finalized within 15 days of the last date of counselling.

(ix) 85% seats would be reserved for the candidates from within the state of Punjab and 15% will be open to all candidates from outside the State. The eligibility criteria for 85% seats will be that the candidates should be a resident of Punjab State in terms of Punjab Govt., Department of Personnel and Administrative Reforms (PP II Branch) letter no. 1/3/95-3PP II/9619 dated 6th June 1996 and letter no. 1/3/95-3PP II / 81 dated 1st Jan 1999, or have passed 10+1 and 10+2 examination as a regular candidate from recognized institutions situated in Punjab. However Children of Defence Personnel posted in Punjab are exempted from this condition to the extent that they should have passed only qualifying examination i.e. 10+2 from a recognized institution situated in Punjab. Each candidate would be required to submit a certificate to this effect from the Principal / Head of Institution last attended in the prescribed Performa.

(x) There shall be a joint Centralized Counselling by I. K. Gujral Punjab Technical University with representatives from all the other Universities.

(xi) There shall be two rounds of Centralized Counselling by I. K. Gujral Punjab Technical University, Kapurthala. The procedure of Centralized online Counselling will be decided by the I. K. Gujral Punjab Technical University, Kapurthala. Thereafter the direct admissions at the college level shall be allowed for vacant seats. The I. K. Gujral Punjab Technical University, Kapurthala will issue necessary instructions to the Institutions / University in this regard.

(xii) Any seat falling vacant after counselling or any drop out vacancy will be filled by the concerned private institute/college on the criteria of admission under management quota. A seat once accepted shall not be changed.

(xiii) The information about the eligibility for admission to degree courses in Engineering Colleges and Departments of Universities and also about the institution/ discipline/ category-wise availability of seats and reservation of seats for various categories shall be made available by I. K. Gujral Punjab Technical University, Kapurthala on website www.ptu.ac.in.

(xiv) As per All India Council for Technical Education Revised Academic Calendar for A/Y 2021-22 issued on dated 12.07.2021, which is attached as annexure, the last date upto which students can be admitted against vacancies arising due to any reason(no student should be admitted in any institution after the last date under any quota) is 20.10.2021. Hence admissions to various degree courses shall be allowed only once in an academic session.

(xv) If any new Institution is approved or seats are increased/altered in the existing institutions by the AICTE and such approval is received before the commencement of that particular round of counselling, I. K. Gujral Punjab Technical University will publish on the official website and invite additional Choice preference from the registered candidates, at the till end of their original choices, without, however, altering the previous choice. These new institutes as well as existing Institutes having addition / alternation in seats shall be taken into consideration before the start of choice filling of that particular round.

(xvi) The fee structure for Foreign Nationals/PIO shall be the same as was in vogue for NRI candidates.

(xvii) The guidelines for admission of Foreign Nationals / PIO shall be as per Punjab Government Notification No. 13/75/2001-ITE2/296 dated Chandigarh the 23rd January, 2002.

(xviii) The guidelines for admission of Kashmiri migrants shall be as per Notification of Punjab

Government in this regard.

(xix) The guidelines for admission of Sikh minority community students to Guru Nanak Dev Engineering College, Ludhiana and Baba Banda Singh Bahadur Engineering College, Fatehgarh Sahib shall be as per Punjab Government Notification No.18/33/2001-GC(6)/4513 dated Chandigarh, the 3rd April, 2001.

(xx) Non refundable counselling fee of Rs. 2000/- (Rupees Two Thousand only) will be collected by the University as counselling fee from each student one time only.

(xxi) In case a student changes his/her college/University allotted during centralized counselling conducted by I. K. Gujral Punjab Technical University, Kapurthala his / her fee shall be refunded by the previous Institution after deduction of Rs. 1000/- only and the original documents will be returned immediately. However, in case of upgradation of seats during subsequent counselling no deduction shall be made.

(xxii) In case a student surrenders his / her seat within 7 days of the end of the Centralized Counseling, he / she must submit application to the college and register on I. K. Gujral Punjab Technical University website www.ptu.ac.in.I. K. Gujral Punjab Technical University shall only forward such cases to the concerned colleges/Universities and colleges must refund his/her full fee after deduction of Rs. 1000/- only.

(xxiii) In keeping with the direction of Ministry of Human Resource Development Department, Govt. of India all Institutions and Universities shall in public interest, maintain a waiting list of students/ candidates. In the event of a student/ candidate withdrawing before the starting of the course, the wait listed candidates should be given admissions against the vacant seat. The entire fees collected from the student, after a deduction of the processing fee of not more than Rs. 1000/- (Rupees One Thousand only) shall be refunded and returned by the Institution/ University to the student/ candidate withdrawing from the programme. It would not be permissible for institutions and universities to retain the certificates in original. If a student leave after joining the course and if the seat consequently falling vacant gets filled by another candidate by the last date of admission, the institution must return the fees collected with proportionate deductions of monthly fee and proportionate hostel rent, where applicable.

(xxiv) All Institutions affiliated to I. K. Gujral Punjab Technical University and Maharaja Ranjit Singh Punjab Technical University shall follow 'Fee Waiver Scheme' as prescribed by AICTE and notified by Government of Punjab vide its notification No. 13/60/08-1TE2/1797, dated 23rd May, 2011, Notification No. 13/60/08-1TE2/2007 dated 31.5.2012, Letter No. 751-752/S-I/ECC/2015 dated 13.05.2015 and Letter No. 428-430 dated 04.04.2019. Other Institutions/ Universities may notify their respective fee waiver scheme separately.

(xxv) As per section 7 of the Aadhaar Act, 2016, use of Aadhaar Authentication Services while identifying beneficiaries and processing the benefit under any scholarship scheme of government is mandatory. The Universities shall adhere to the guidelines and regulations defined by Unique Identification Authority of India (UIDAI).

E. OVER-RIDING PROVISION

Nothing in this notification shall be operative in so far as it is inconsistent with the law of the land as laid down in the judgment of the honorable Supreme Court of India in the case of TMA Pai Foundation and others vs. State of Karnataka and others (2002) 8SCC 481:AIR 2003 SC 355). Any such inconsistency may be brought to the notice of the Department of Technical Education, Government of Punjab, for immediate rectification.

Anurag Verma, IAS
Principal Secretary to Govt. of Punjab,
Deptt. of Technical Education &Indl. Training

Dated, Chandigarh the
12-08-2021

Endst. No. TECH-TE-2013/4/2021-4TE2/1/229119/2021 (1-4) Dated: 13/08/2021

A copy is forwarded to the following for information and necessary action:-

1. The Director, Technical Education & Industrial Training, Punjab, Chandigarh.
2. The Vice Chancellor, Maharaja Ranjit Singh Punjab Technical University, Bathinda
3. The Vice Chancellor, I. K. Gujral Punjab Technical University, Kapurthala
4. The Vice Chancellor, Punjab Agricultural University, Ludhiana
5. The System Analyst, Computer Section, Office of the Director, Technical Education & Industrial Training, Punjab, Chandigarh.
6. Sh. Umesh Chander, Superintendent Grade-1, O/o Director, Technical Education & Industrial Training, Punjab, Chandigarh for uploading on the portal of Controller, Printing and Stationery, Punjab, Chandigarh for requested that the notification may be published in the State Govt. extra-ordinary Gazette and 20 copies of the notifications may be supplied to Government for record.

o/c Under Secretary

GOVERNMENT OF PUNJAB
DEPARTMENT OF TECHNICAL EDUCATION AND INDUSTRIAL TRAINING
(TECHNICAL EDUCATION BRANCH - II)

NOTIFICATION

No. TECH-TE-2013/4/2021-4TE2/ 1/੨੨੧੧੨੦/੨੦੨੧   Dated: 13/08/੨੦੨੧

1.0 The Governor of Punjab is pleased to appoint the I. K. Gujral Punjab Technical University, Kapurthala as the authority competent toconduct the Centralized Counselling to make admission of Diploma Holder/B.Sc. to the 2nd year/3rd semester of the Graduate Programme Engineering & Technology. The admission shall be made in the colleges affiliated to Universities and Campuses of the Universities mentioned below:-

1. I. K. Gujral Punjab Technical University, Kapurthala
2. Maharaja Ranjit Singh Punjab Technical University, Bathinda

- Lateral Entry to Second Year Degree Course(s) in Engineering and Technology Programme shall be permissible up to maximum of 10% of the "Approved Intake" of previous year, which shall be over and above, supernumerary to the "Approved Intake", plus the unfilled vacancies of the First year as specified in the Approval Process Handbook.

2.0 The Governor of Punjab is also pleased to further issue the following criteria for making admissions:

A. ELIGIBILITY CRITERIA FOR DIPLOMA HOLDERS

(i) All those candidates who have passed minimum three years/two years (Lateral Entry) Diploma examination from an AICTE approved institution/recognized university as defined by UGC with at least 45% marks (40% in case of Candidates belonging to reserved category) in any branch of Engineering and Technology shall be eligible to apply.

OR

(ii) All those candidates who have passed B. Sc. Degree from a recognized University as defined by UGC, with at least 45% marks (40% in case of Candidates belonging to reserved category) and passed XII standard with mathematics as a subject shall be eligible to apply.

OR

(iii) Passed D.Voc. stream in the same or allied sector.

((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)

B. GENERAL ELIGIBILITY CRITERIA FOR ADMISSION TO DEGREE LEVEL ENGINEERING, TECHNOLOGY COURSE:

(i) The admission of candidates to the Engineering courses under this scheme shall only be given to those, who fulfill all other conditions for admission. In case of seats reserved for SC/ST, the relative merit of candidates shall be determined within the reserved category.

(ii) Candidates who have appeared / are appearing in the qualifying diploma examination to be held during the current session shall also be eligible for submission of admission form but they will have to pass the diploma before the date of counselling, otherwise, they will not be considered for admission. Such candidates will not have any claim, whatsoever, with regard to the admission to the courses.

(iii) The guidelines issued for the grant of resident certificates / bonafide resident of Punjab by Department of Personnel and Administrative Reforms (PP-2 Branch) vide No. 1/3/95-3PP-2/9619 dated the 6th June, 1996, and I.D. No. 1/2/96-3PP-2/8976 dated 7th July, 1998 and No. 1/3/95-3PP-2/80 dated 1st January 1999, and further instructions, issued by that Department, if any, will be adhered to in letter and spirit while making admission to the Degree Courses in the Engineering Colleges. However, children of defence personnel posted in Punjab are exempted from this condition to the extent that they should have passed only qualifying examination from a recognized institution situated in Punjab.

(iv) Apart from the basic educational qualifications prescribed above, the general eligibility criteria shall be as contained in Punjab Government, Department of Technical Education & Industrial Training, Memo No. 35/44/95-1T(2)/978 dated 21st March, 2003, which is annexed to this notification. This communication shall be treated as a part and parcel of this notification, for all purposes, and all the provisions of this notification shall be read along with the contents of the said communication.

Exemption under above para

Children / Wards / Dependent (whose parent are not alive) of all those regular Punjab Government Employees, members of All India Service borne on Punjab Cadre, Serving Judges and the employees of the Punjab and Haryana High Court, employees of Boards / Corporations / Statutory Bodies established by an Act of the State of Punjab who have been holding post outside Punjab on or before 1st January of the year of admissions that is on or before 1st January, 2020 and their children / wards / dependents have completed qualifying examination outside Punjab.

C. RESERVATION:

(i) The reservation of seats shall be as per Punjab Government, Department of Technical Education and Industrial Training Memo. No. 13/2/05-1TE2/1987 dated 2nd July, 2013 and Memo no.8/41/2019-4TE2/53 dated 13.09.2019, which are attached as Annexures. This communication shall be treated as a part and parcel of this notification for all purposes and all the provisions of this notification shall be read along with the contents of the said communication.

(ii) The attention of the applicants desirous of claiming reservation under any category whatsoever is especially drawn to the condition and stipulation that only the certificates that have been produced at the time of admission shall be considered. The candidates are accordingly advised, in their own interest, to get the requisite certificates issued well before the date of admission, otherwise, claim for reservation shall be summarily rejected. Candidates are required to claim reservation at the time of registering for counselling. If no reservation is claimed the candidate shall be treated and considered as a "General Category Candidate".

(iii) The I. K. Gujral Punjab Technical University shall make a provision in the online application form for a candidate to indicate the category, if any, under which he/she is seeking reservation. There shall also be a provision to indicate the sub-category of the category, if any, under which reservation is being sought, so that inter-se gradation can be facilitated. These sub-categories have been elucidated in the Punjab Government, Department of Technical Education and Industrial Training Memo. No. 13/2/05-1TE2/1987 dated 2nd July, 2013 and Memo no.8/41/2019-4TE2/53 dated 13.09.2019, which are attached as Annexures. Punjab Government may also set up a committee to effect inter-se gradation of candidates claiming reservation under certain categories, as indicated in the aforesaid memo dated 2nd July, 2013 and dated 13th September, 2019.

(iv) A candidate shall be eligible to make claim for reservation in any reserved category. However, the procedure for counselling shall be as per Punjab Government, Welfare Department (Reservation Cell) Memo No.7/21/2004-RS1/1674-1677 dated 20th Dec. 2004.

D. GENERAL CONDITIONS:

(i) There shall be centralized Centralized Counselling by I. K. GujralPunjab Technical University.

(ii) There shall be two rounds of Centralized counseling by I. K. Gujral Punjab Technical University, Kapurthala. The procedure of Centralized Online Counselling will be decided by the I. K. Gujral Punjab Technical University, Kapurthala. Thereafter the direct admissions at the college level shall be allowed for vacant seats. The I. K. Gujral Punjab Technical University, Kapurthala will be issue necessary instructions to the affiliated Institutions of University in this regard.

(iii) As per All India Council for Technical Education Revised Academic Calendar for A/Y 2021-22 issued on dated 12.07.2021, which is attached as annexure, the last date upto which students can be admitted against vacancies arising due to any reason(no student should be admitted in any institution after the last date under any quota) is 20.10.2021.Hence admissions to various degree courses shall be allowed only once in an academic session.

(iv) The students shall be liable to pay Fee / Development Fee and other charges as per the rates of Fee / Development Fee and other charges as fixed by the Government of Punjab/AICTE/ Concerned University, from time to time.

(v) The management quota shall be as per Punjab Govt., Deptt. of Technical Education and Industrial Training Memo no. 13/129/2003-1TE2/1247 dated 25th April 2008 and Partial notification no. 13/129/2003-1TE2/1892 Dated 20th June 2008 and partial notification no. 13/129/2003-1TE2/171 dated 18th January 2011, which is as Annexed.

(vi) The allocation of seats through counselling shall be done as follows:

(a) Counselling for 85% seats for Punjab residents and 15% outside Punjab candidates shall be taken up simultaneously. However, the reserved category candidates shall be considered in general category first before being considered in respective reserved category.

(b) The seats still remaining unfilled even after the end of Centralized Counselling shall be filled on merit at the level of Institution. Admission to such unfilled/vacant seats as well as management quota shall be furnished to I. K. Gujral Punjab Technical Universityand details thereof shall be finalized within 15 days of the last date of counselling.

(vii) Any seat falling vacant after counselling or any drop out vacancy will be filled by the Institute on the basis of the criteria of admission under management quota. A seat once accepted shall not be changed.

(viii) The information about the eligibility for admission to Lateral Entry courses in Engineering Colleges and Departments of Universities and also about the institution/ discipline/ category-wise availability of seats and reservation of seats for various categories shall be made available by I. K. Gujral Punjab Technical University, Kapurthala on website www.ptu.ac.in.

(ix) The guidelines for admission of Foreign Nationals/Person of India Origin shall be as per Punjab Government Notification No. 13/75/2001-1TE2/296 dated Chandigarh the 23rd January, 2002.

(x) The guidelines for admission of Kashmiri migrants shall be as per notification of Punjab Government in this regard.

(xi) Non refundable counselling fee of Rs. 2,000/- (Rupees Two Thousand only) will be collected by the University as counselling fee from each student one time only.

(xii) In case a student changes his/her College/University during centralized counselling conducted by I. K. Gujral Punjab Technical Universityhis/her fee shall be refunded by the pervious Institution after deduction of Rs 1,000/- only the original documents will be refunded immediately. However, in case of up-gradation of seats during subsequent counselling's no deduction shall be made.

(xiii) In case a student surrenders his/her seat, within 7 days of the end of the Centralized online Counselling, he/she must submit application to college and register on I. K. Gujral Punjab Technical Universitywebsite www.ptu.ac.in. I. K. Gujral Punjab Technical Universityshall only forward such cases to the concerned Colleges/ Universities and Colleges must refund his/her full fee after detection of Rs. 1,000/- only.

(xiv) In keeping with the direction of Ministry of Human Resource Development Department, Govt. of India, all Institutions and Universities shall in public interest, maintain a waiting list of students/candidates. In the event of a student/ candidate withdrawing before the start of the course, the waiting list candidates should be given admissions against the vacant seat. The entire fees collected from the student, after a deduction of processing fee of not more than Rs. 1,000/- (Rupees One Thousand Only) shall be refunded and returned by the Institution/University to the student/candidate withdrawing from the programme. It would not be permissible for Institutions and Universities to retain the School/Institution leaving certificates in original. If a student leaves after joining the course and if the seat subsequently falling vacant gets filled by another candidate by the last date of admission, the Institution must return the fees collected with proportionate deduction of monthly fee and proportionate hostel rent, where applicable.

(xv) All Institutions affiliated to I. K. Gujral Punjab Technical University and Maharaja Ranjit Singh Punjab Technical University shall follow 'Fee Waiver Scheme' as prescribed by AICTE and notified by Government of Punjab vide its notification No. 13/60/08-1TE2/1797, dated 23rd May, 2011, Notification No. 13/60/08-1TE2/2007 dated 31.5.2012, Letter No. 751-752/S-I/ECC/2015 dated 13.05.2015 and Letter No. 428-430 dated 04.04.2019. Other Institutions/ Universities may notify their respective fee waiver scheme separately.

(xvi) As per section 7 of the Aadhaar Act, 2016, use of Aadhaar Authentication Services while identifying beneficiaries and processing the benefit under any scholarship scheme of government is mandatory. The Universities shall adhere to the guidelines and regulations defined by Unique Identification Authority of India (UIDAI).

E. OVER-RIDING PROVISION:

Nothing in this notification shall be operative in so far as it is inconsistent with the law of the land as laid down in the judgement of the Hon'ble Supreme Court of India in the case of T.M.A. Pai Foundation and others Vs. State of Karnataka and others ([2002] 8 SCC 481:AIR 2003 SC 355). Any such inconsistency may be brought to the notice of the Government of Punjab, clearly highlighting the inconsistency, for immediate rectification.

Anurag Verma, IAS
Principal Secretary to Govt. of Punjab,
Deptt. of Technical Education &Indl. Training

Dated, Chandigarh the
12-08-2021

Endst. No. TECH-TE-2013/4/2021-4TE2/1/229120/2021 (1-4) Dated: 13/08/2021

A copy is forwarded to the following for information and necessary action:-

1. The Director, Technical Education & Industrial Training, Punjab, Chandigarh.
2. The Vice Chancellor, Maharaja Ranjit Singh Punjab Technical University, Bathinda
3. The Vice Chancellor, I.K. Gujral Punjab Technical University, Kapurthala
4. The System Analyst, Computer Section, Office of the Director, Technical Education & Industrial Training, Punjab, Chandigarh.
5. Sh. Umesh Chander, Superintendent Grade-1, O/o Director, Technical Education & Industrial Training, Punjab, Chandigarh for uploading on the portal of Controller, Printing and Stationery, Punjab, Chandigarh for requested that the notification may be published in the State Govt. extra-ordinary Gazette and 20 copies of the notifications may be supplied to Government for record.

O/C Under Secretary

Content

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Syllabus

1. **Classical Mechanics**: Centre of Mass, Motion of Centre of mass, Pure Translational and Rotational motion, Torque and angular momentum, Principle of moments (Moment of Inertia), Radius of Gyration, Generalized Motion, Kinematics of rotational motion about a fixed axis.

2. **Mechanical Properties of Solids and Fluids**: Elastic behaviors of solids, Hooke's Law, Young's Modulus, Shear Modulus, Bulk Modulus, Applications of Elastic behaviors of materials, Compressibility, Viscosity, Relative density, Pascal's Law, Streamline Flow, Bernoulli's Principle, Surface Tension, Drops and Bubbles

3. **Waves and Oscillations**: Rectilinear motion, Oscillations or Vibrations, Simple Harmonic Motion, Damped Harmonic motion: Real oscillatory system, Forced or Driven oscillation, TYPES OF WAVES, Superposition of Waves, Reflection and Refraction, Standing Waves and Normal Modes, Beats, Resonance, Doppler's Effect

4. **Electricity and Magnetism:** Physical concepts of gradient, divergence, and curl; Laplacian operator, Concept of electricity and magnetism, Coulomb's law, Electrostatics, Magnetostatics, The Lorentz force, Maxwell's equations

5. **Electromagnetic Signal**: Introduction to Maxwell's equations, The dynamical magnetic field, The dynamical electric field, Electromagnetic Waves

6. **Wave Optics:** Interference of light, Photons, Young's Double Slit Experiment, Huygens's Principle, Diffraction, Diffraction Grating, Polarization

7. **Semiconductor Electronics**: Classification of metals, conductors and semiconductors, Fermi Level, Intrinsic Semiconductor, Extrinsic Semiconductor, *p-n* junction, Semiconductor Diode, Half-Wave Rectifier, Full-Wave Rectifier, Zener diode, Photodiode, Light emitting diode, Junction Transistor

8. **Modern Physics**: Wave nature of light, Particle nature of light: the photon, De Broglie Hypothesis, Experimental confirmation of de Broglie hypothesis (Davisson and Germer's Experiment)

9. **Atomic and Nuclear Physics**: Matters, Atoms, Atomic Theory: Atomic Theory by John Dolton, Atomic Theory by J. J Thompson, Atomic Theory by Ernest Rutherford, Atomic Theory by James Chadwick, Discovery of the Neutron, Bohr's Postulates, Proton, Neutron, Electron, Limitations of Bohr's Theory