M.S.D. State University, Azamgarh (U.P.)

M.Sc. (PHYSICS) TWO YEAR (SEMESTER SYSTEM)

COURSE STRUCTURE AND SYLLABUS

Effective from 2022-23

15/9/22
(Prof. Afsar Ali)
Dean

(S. Tahir Husain)
Convener

P.G. PHYSICS

M. S. D. State University, Azamgarh
Syllabus

Semester Courses of M.Sc. (Physics) Based on CBCS

The course of M.Sc. (Physics) will be spread over two years - Previous & Final. There will be two semester examinations and a Lab (Practical examination) & Major Research Project work examination every year.

Course Objectives and Outcomes:

- To provide a supportive and cooperative environment to the students to impart systematic and core knowledge of the subject matter based on sound theoretical, experimental and computational foundation.
- To provide a course of the highest academic quality in various disciplines of Physics: Core/Optional/Elective/Allied courses in an atmosphere of relatively less number of specialized faculties, insufficient lab facilities, basic infrastructure and local geographical conditions so as to produce teachers and researchers and technical hands of high excellence to beat with frontiers of international repute.
- To develop transferable skills of critical discussion, solving complex, unseen and open ended problems.
- To develop transferable technical and teaching skills to the serve the human kind.
- To develop a temperament of working in an organized and time bound manner so as to achieve the academic/research target within given time line with all due consideration of practical realities.
- To motivate the students to know the scope and significance of Physics Education in the real world that the Physics is the most basic of all sciences which enables us to understand the nature, natural phenomenon and the governing laws at their most fundamental levels.
- To make the students realize to establish a Nation of scientifically and technically literate fellows with a rigid moral ground by contributing through their own developed skills and knowledge.
- Above all, to produce good human beings holding science and technology as tools ready to serve the world beyond all the boundaries.

M.Sc. (Physics)

(Effective from session 2022-2023)

The M.Sc. Physics Course consists of four Semesters (2 Sems in each year). The Examinations of Sem-I and Sem-II will be held in the months of December and April, respectively. Each Semester Examination will consist of Theory Papers of that Semester as well as One Practical Examination (Lab). Each Theory paper will be of three hours duration and of 4 credits (Maximum Marks 75) and the Practical Examination will be of two hours (Maximum Marks 75). There will be 25% internal evaluation in each, theory as well as in practical examination as shown below:

25% Internal Assessment in Theory		**25% Internal Assessment in Lab**	
Attendance/Interaction	5 Marks	Attendance/Interaction	5 Marks
Sessional Test	10 Marks	Lab Assignment	10 Marks
Assignment	10 Marks	Viva-Voce	10 Marks

Format of the Question Paper:

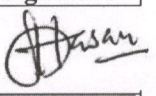
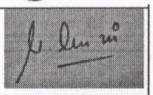
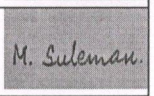
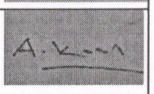
There will be Section-A of one Compulsory Question consisting of 10 parts of Very Short answer type question. Each part will have to be answered in about 50 words. Section-B will consist of five Short Answer type questions each with internal choice. Each question will have to be answered in about 200 words. Section-C will consist of five Long Answer type questions. Any two questions from Section-C will have to be attempted. Each question will have to be answered in about 500 words.

M.Sc. Physics

Year	Semester	Category/Type of the Courses	Course Code	Paper Title	Theory / Practical	Credits
First Year	VII	Major/Compulsory	B010701T	Mathematical Physics	Theoretical	4
			B010702T	Classical Mechanics	Theoretical	4
			B010703T	Quantum Mechanics-I	Theoretical	4
			B010704T	Analog & Digital Electronics	Theoretical	4
			B010705P	General Lab	Practical	4
			B010706R	Major Research Project	Project	4
		Minor/Compulsory	B010707T	**May be opted from the pool of closely related Major Subjects. So syllabus for Minor papers will not be developed**	Theoretical	4-6
	VIII	Major/Compulsory	B010801T	Relativistic Mechanics & Classical Electrodynamics	Theoretical	4
			B010802T	Statistical Physics	Theoretical	4
			Optional	**Choose Any Two of the following**		
			B010803T	Plasma Physics	Theoretical	4
			B010804T	Laser & Modern Optics	Theoretical	4
			B010805T	Introduction to Modern Physics	Theoretical	4
			B010806T	Quantum Mechanics-II	Theoretical	4
			B010807P	Electronics Lab	Practical	4
			B010808R	Major Research Project	Project	4
		Minor/ Compulsory	B010809T	**Same instructions will be followed as indicated in Semester-VII above**	Theoretical	4-6
	IX	Major/Compulsory	B010901T	Fundamentals of Nuclear and Particle Physics	Theoretical	4
			B010902T	Solid State Physics	Theoretical	4
			Optional	**Choose Any Two of the following**		
			B010903T	Classical Field Theory	Theoretical	4
			B010904T	Electronics-II	Theoretical	4
			B010905T	Atomic and Molecular Physics	Theoretical	4
			B010906T	Experimental Techniques	Theoretical	4

Second Year			B010907P	General & Optics Lab	Practical	4
		Major Research Project	B010908R	Major Research Project	Project	4
	X	**Major/Compulsory**	**Optional**	**Choose any four of the following**		
			B011001T	Advanced Solid State Physics	Theoretical	4
			B011002T	Quantum Field Theory& QED	Theoretical	4
			B011003T	Electronic Communication	Theoretical	4
			B011004T	Liquid Crystal Physics	Theoretical	4
			B011005T	High Energy Physics	Theoretical	4
			B011006T	Astronomy & Astrophysics	Theoretical	4
			B011007T	General Theory of Relativity & Cosmology	Theoretical	4
			B011008T	Environmental Physics	Theoretical	4
			B011009P	Special Lab	Practical	4
		Major Research Project	B011011R	Research Project	Project	4

Syllabus developed and approved by: B.O.S. (Physics)

S.N	Name	Designation	Department	College/University	Email/Phone	Signature
1	Syed Tahir Husen (Convener)	Associate Professor	Physics	Shibli National College, M. S. D. U. Azamgarh	sthasan0265@gmail.com	
2	Dr. Imran Aziz	Associate Professor	Physics	Shibli National College, M. S. D. U. Azamgarh	azizimran33@gmail.com	
3	Dr.Mohd Suleman	Assistant Professor	Physics	Shibli National College, M. S. D. U. Azamgarh	mdslmn@gmail.com	
4	Dr. Arshad Kamal	Assistant Professor	Physics	Shibli National College, M. S. D. U. Azamgarh	arshadhep@gmail.com	
5	Dr. Nazeer Ahmad	Associate Professor	Physics	A. M. U. Aligarh	Nazeerahmadna @gmail.com	
6	Dr. Sudesh Singh	Associate Professor	Physics	T. D. College Jaunpur	sudeshkumarsingh @gmail.com	

P.G. PHYSICS

Programme/Class: **M. Sc.**	Year: **First**	Semester: **VII**
Subject: **Physics**		
Course Code: **B010701T**	Course Title: **Mathematical Physics**	

Course Objectives & Outcomes

Objective: To sharpen the Mathematical acumen of the students so that they can apply Mathematical ideas and tools wherever needed.

Outcomes: After completing this course the students will be able to apply ideas of Group Theory to Solid State Physics, of partial differential equations specially the Bessel functions to understand the phenomenon of diffraction, frequency modulation and theory of Klystron amplifiers, etc.

Credits:**4**	Course: **Core Compulsory**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week):L-T-P:**4-0-0**

Unit	Topics	No. of Lectures
I	**Matrices and Tensors** Basic properties of matrices (Review only), Orthogonal matrices, Hermitian and Unitary matrices, Similarity and unitary transformations, Diagonalization of matrices, Definition of Tensors, Contraction, Direct products,, quotient rule, Pseudo tensors, Dual tensors, Levi Cevita symbol.	9
II	**Functions of Complex Variables** Introduction, Analyticity, Cauchy-Reimann conditions, Cauchy's integral theorem and integral formula, Calculus of residues and applications.	7
III	**Special function** Green's function, one -dimensional Green's function and Dirac delta function, Gamma function, Beta function, Bessel function, Hermite polynomials, Legendre polynomials.	8

IV	**Second Order Differential Equations** Partial differential equations of Physics, Separation of variables, Singular points, Ordinary series solution.	6
V	**Fourier Series** General properties, Advantages, Uses of Fourier series, Properties of Fourier series, Dirichlet's conditions.	6
VI	**Group Theory** Symmetry elements and symmetry operations, Point group and their representation, , Matrix representation, Great Orthogonality theorem (statements and interpretation only), Reducible and irreducible representations, characterization of electronic states and vibrational model of polyatomic molecules, character tables of C_{2v}	9

Suggested Readings

1. Matrices and tensors by A.W. Joshi

2.Mathematical Methods for Physicists by G.B. Arfken and H. J. Weber

3. Mathematical Methods for Physics by J. Mathews and R. Walker

4. Advanced Engineering Mathematics by Erwin Kreyzig

Course BookspublishedinHindimaybeprescribedbytheUniversities.

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Suggestive Digital Platforms/Web Links
1. MITOpenLearning-MassachusettsInstituteofTechnology,https://openlearning.mit.edu/ 2. NationalProgrammeonTechnologyEnhancedLearning(NPTEL),https://www.youtube.com/user/nptelhrd 3. UttarPradeshHigherEducationDigitalLibrary,http://heecontent.upsdc.gov.in/SearchContent.aspx 4. SwayamPrabha-DTHChannel,https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as a Core (Compulsory) by the students of following subjects
M.Sc.-I, Sem-I
Suggested Continuous Internal Evaluation(CIE)Methods
20 marks for Test/Quiz/Assignment / Seminar 05 marks for Class Interaction
Course Prerequisites
Suggested Equivalent Online Courses
1. Coursera,https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX,https://www.edx.org/course/subject/physics 3. MITOpenCourseWare-MassachusettsInstituteofTechnology,https://ocw.mit.edu/courses/physics/ 4. Swayam-GovernmentofIndia,https://swayam.gov.in/explorer?category=Physics 5. NationalProgrammeonTechnologyEnhancedLearning(NPTEL),https://nptel.ac.in/course.html
Further Suggestions
• Other digital platforms /web links and Equivalent online courses may be suggested /added to the respective lists by individual Universities. • In End-semester University Examination, equal weightage should be given to each unit 1-V while framing the questions.

Programme/Class: **M. Sc.**	Year: **First**	Semester: **VII**
Subject: **Physics**		
Course Code: **B010702T**	Course Title: **Classical Mechanics**	

Course Objectives & Outcomes

Course Objective: To provide a course of the highest academic quality with deep knowledge and understanding in an atmosphere of relatively less facilities, basic infrastructure and odd geographical conditions so as to produce teachers and researchers of high excellence to beat with frontiers of international repute.

Course Outcomes: The students will be able to solve complex problems with larger degrees of freedom using the elegant and simpler approach of this course including Lagrangian, Hamiltonian and other formalisms.

Credits: **4**	Course: **Major (Compulsory)**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Lagrangian and Hamiltonian Formalism:** Review of Galilean and Newtonian concept of motion, types of constraints, generalised coordinates, principle of virtual work, D'Alembert's principle, calculus of variations; Hamilton's principle; principle of stationary/least action, shortest distance, brachistochrone problem, Lagrange's equation from Hamilton's principle, velocity-dependent potentials, generalised momentum and generalised force, canonical equations of motion (Hamilton's equations), cyclic coordinate and conservation laws, Lagrangian and Hamiltonian for central forces, electromagnetic forces.	**14**
II	**Canonical transformations:** Poisson bracket formalism, infinitesimal canonical transformations, examples of canonical transformation, action-angle variables in systems in one dimension and for separable systems, conservation theorems in Poisson bracket formalism; invariance of Poisson bracket under canonical transformations, Jacobi's identity; angular momentum Poisson bracket relations, Poisson bracket relations, phase space, Liouville's equation.	**14**

III	**Keplers Problem, Symmetry and Conservation Laws:** Review of two body central force problem (classification of orbits, equation of orbits, Bertrands theorem, Kepler problem), Virial theorem, Integrable power-law potentials, gauge transformation of Lagrangian, Noether's theorem, spatial translations, temporal translation, and spatial rotations and the related conservation laws.	**10**
IV	**Rigid Body Motion:** Independent coordinates; orthogonal transformations and rotations (finite and infinitesimal), Euler's angles and Euler's theorem on the motion of a rigid body, angular momentum and the kinetic energy about a point, moment of inertia tensor, eigenvalues of the inertia tensor and the principal axis transformation, solution of problems with Euler's equations, symmetrical top, precession of Earth's axis of rotation and a charged particle in magnetic field.	**14**
V	**Small Oscillations:** General formalism of small oscillations, eigenvalue equation and the principal axis transformation, frequencies of free vibration and normal coordinates, coupled oscillators, forced oscillations, parametric resonance.	**8**

Suggested Readings

[1] H. Goldstein, C. Poole, J. Safko, Classical Mechanics, (Pearson, 2001).
[2] L. Landau, E.M. Lifshitz, Mechanics (Pergamon, 1976).
[3] N.C. Rana, P. S. Joag, Classical Mechanics (Tata McGraw-Hill, 2017).

Course Books published in Hindi may be prescribed by the Universities.

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Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as a Major (Compulsory) by the students of following subjects
M. Sc.-I, Sem-I
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test/Quiz/Assignment /Seminar 05 marks for Class Interaction
Course Prerequisites
Passed Degree Course in Physics
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
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Programme/Class: **M. Sc.**	Year: **First**	Semester: **VII**
Subject: **Physics**		
Course Code: **B010703T**	Course Title: **Quantum Mechanics-I**	

Course Objective & Outcomes

Course Objective:

1. To acquire knowledge of mathematical tools which is applied to understand the Quantum Mechanics
2. To acquire the knowledge of postulates of Quantum Mechanics, angular momentum, addition of angular momenta, and identical particles

Course Outcomes:

1. To understand the significance of mathematical tools in Quantum Mechanics
2. The student recognizes that learning these topics are stepping stone to understand advanced quantum mechanics.

The topics covered in the syllabus show an understanding of postulates of Quantum Mechanics, angular momentum, addition of angular momentum, and identical particles

Credits: **4**	Course: **Core (Compulsory)**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Mathematical Tools of Quantum Mechanics:** Linear Vector Spaces. Elements of Hilbert Space. Dirac Notation. Operators: Hermitian and Projection Operators, Inverse and Unitary Operators, Functions Operators, Eigenvalues and Eigenvectors of Operators. Commutator Algebra. Unitary Transformations and Change of Basis. Matrix Representation of Operators. Continuous Basis, Position and Momentum Representation and their Position Connection. Parity Operator.	15
II	**Postulates of Quantum Mechanism:** Basic Postulates of Quantum Mechanics. Measurement in Quantum Mechanics. Time Evolution of System's State. Connecting Quantum to Classical Mechanics: Poisson Brackets and Commutators, The Ehrenfest Theorem. Simple Harmonic Oscillator by Operator Methods.	15
III	**Angular Momentum:** Orbital Angular Momentum Operators and their Commutation Relations. Eigenvalues and Eigen functions of L^2 and L_z. Spin Angular Momentum: Stern-Gerlach Experiment. Spin Angular Momentum Operators, Pauli's Spin Matrices and Their Commutation Relations. General Formalism of Angular Momentum. Matrix Representation of Angular Momentum.	7

IV	**Rotations and Addition of Angular Momenta:** Rotation in quantum Mechanics: Infinitesimal Rotations, Finite Rotations, Euler Rotations. Addition of Angular Momenta, Clebsch-Gordan Coefficients and their Properties.	7
V	**Identical Particles:** Identical Particles in Quantum Mechanics. Exchange Degeneracy, Symmetric and anti-symmetric Wave functions. Construction of Symmetric and anti-symmetric Wave functions from Unsymmetrized Wave funcions. Distinguishability of Identical Particles. The Pauli Exclusion Principle.	8

Suggested Readings

1. Quantum Mechanics: Concepts and Applications: N. Zettili
2. Modern Quantum Mechanics: J. J. Sakurai
3. Quantum Mechanics: L. I. Schiff
4. Introduction to Quantum Mechanics: David J. Griffiths
5. Principles of Quantum Mechanics: P. A. M. Dirac

Course Books published in Hindi may be prescribed by the Universities.

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Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as an Elective by the students of following subjects
M.Sc.-I, Sem-I
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar/ 05 marks for Class Interaction
Course Prerequisites
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
• Other digital platforms /web links and Equivalent online courses may be suggested /added to the respective lists by individual Universities. • In End-semester University Examination, equal weightage should be given to each unit 1-V while framing the questions.

Programme/Class: **M. Sc.**	Year: **First**	Semester: **VII**
Subject: **Physics**		
Course Code: **B010704T**	Course Title: **Analog and Digital Electronics**	

Course Objective & Outcomes

Course Objective:
To understand the course of transition from analog to digital world. To apply the gained knowledge in understanding the working of daily-life electronic systems.

Course Outcomes:
After completing the course, the candidate will be able to:
(i) Understand how Op-amp and Timers can serve as a source of an infinite train of pulses (Clock).
(ii) Understand the limitations of Op-amp.
(iii) Understand how data is converted from analog to digital form for instance in a digital multimeter.
(iv) How counting machines utilize binary counters.
(v) Know the data storage capacity of a semiconductor memory. To understand the terms Kilobyte, Megabyte, Gigabyte, Terabyte etc.
(vi) know how two smaller capacity memory units can be combined to produce a larger memory unit.

Credits: **4**	Course: **Core (Compulsory)**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Analog Electronics:** Differential Amplifier, d.c. and a.c. analysis, Integrated circuit operation amplifier, Ideal op-Amp, Basic characteristics, Negative feedback, Inverting and non inverting amplifier, Closed loop gain, Concept of virtual short, Voltage follower, Difference amplifier, Summation amplifier, Integrator and differentiator, Open loop comparator, Schmitt Trigger. Astable and mono stable multi vibrator, Triangular wave generator. 555 Timer. **Non ideal properties of op-Amp:** Output saturation levels, offset voltages and currents, Input bias current, slew rate limitation, Finite freq response, Gain-band width product.	15
II	**Interfacing the analog and digital worlds.** D/A Converter, Binary weighted resistor D/A converter, R-2R Ladder D/A converter, Sample and hold circuit., basic idea of quantization and sampling, converter specifications, A/D converter, Ramp, Flash and Successive Approximation A/D converter. Voltage to frequency and frequency to voltage converter.	10
III	**Digital Electronics: Sequential Circuits** Review of Flip-Flop Characteristic table and characteristic equation, Ripple counter, Mod number, Frequency division, Counter with Mod No $< 2^N$. Change of Mod number. Synchronous counter design, Ring counter, Johnson counter, Counter applications, Digital Clock.	10

IV	**Integrated circuit Logic Family** Classification of IC's on the basis of packing density and family, Logic family characteristics, Transistor as a switch, RTL, DTL and TTL, Open collector, Totem-pole and tri-state output TTL, Current sourcing and sinking action of TTL output, ECL, MOS and CMOS family, Interfacing of TTL & CMOS.	**15**
V	**Memory Devices** Memory terminology, General memory operation, ROM architecture, Read operation, ROM types, Flash memory, ROM applications, Programmable Logic Devices, Semiconductor RAM, RAM architecture, Read and write operations, Static RAM and Dynamic RAM, Expanding word size and capacity.	**10**

Suggested Readings

1. Electronic Principles – A. Malvino, D.J. Bates 7th ed TMH, N. Delhi.
2. Microelectronic Circuit and Devices – Mark N. Horenstein, Pearson 2nd ed.
3. Fundamentals of Analog Circuits – Floyd, Buchla 2nd ed, Pearson – 2017.
4. Digital System – R.J. Tocci, PHI 6th ed, 2000.
5. Digital Logic and Computer Design – M. Morris Mano, PHI, Delhi 1996.
6. Integrated Electronics: Analog and Digital circuits and Systems, J. Millman, C. C. Halkias, TMH, Edition 1991.

Course Books published in Hindi may be prescribed by the Universities.

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Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
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Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar/ 05 marks for Class Interaction
Course Prerequisites
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
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Programme/Class: **M. Sc.**	Year: **First**	Semester: **VII**
Subject: **Physics**		
Course Code: **B010705P**	Course Title: **General Physics Lab**	

Course Objective & Outcomes

Course Objective: The experiments are an essential and inseparable part of Physics Course. The validity of various Laws and observations are tested through experiments in the Lab.

Course Outcomes: The results of an experiment (in agreement/deviated from the established pattern) enable the students to recognise the faults/errors in his approach and encourages to repeat the experiment with an improved approach.

Credits:**01**	Course: **Core (Compulsory)**
Max. Marks: **25+75** One Practical: 40 Marks Record: 10 Marks Viva-Voce: 20 Marks Attendance: 05 Marks.	Min. Passing Marks:

Total No. of Lectures-Tutorials-**Practical (in hours per week)**: L-T-P: 0-0-**2**

	Topics	**No. of Hours**
1.	Hall Effect: Determination of carrier concentration, Hall coefficient and mobility of carriers in a semiconductor sample.	**30**
2.	Determination of Lande's g – factor of a free electron by E.S.R spectrometer (sample: DPPH).	
3.	Magnetic susceptibility by Quincke's tube mehod.	
4.	Measurement of forbidden energy gap in a semiconductor.	
5.	Refractive index of glass by Brewster's law.	
6.	V-I characteristics of solar cell and determination of fill – factor and efficiency.	
7.	Determination of Planck's constant using incandescent bulb, colour filters and solar cell.	
8.	Y. by Newton's ring method.	
9.	R – C coupled amplifier.	
10.	Boltzman Constant.	
11.	Thickness of wire using Laser.	

Note:

- The student has to do a minimum of six experiments from the given list.
- In the practical examination the student will be asked to perform one experiment of two hours duration.

Suggested Readings

1. Electronic Principles – A. Malvino, D.J. Bates 7th ed TMH, N. Delhi.
2. Microelectronic Circuit and Devices – Mark N. Horenstein, Pearson 2nd ed.
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This course can be opted as a Major (Core) by the students of following subjects
M.Sc.-I, Sem-I
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar/ 05 marks for Class Interaction
Course Prerequisites
Passed B. Sc. Degree Course
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
• Other digital platforms /web links and Equivalent online courses may be suggested /added to the respective lists by individual Universities. • In End-semester University Examination, equal weightage should be given to each unit 1-V while framing the questions.

P.G. PHYSICS

Programme/Class: **M. Sc.**	Year: **First**	Semester: **VIII**
Subject: **Physics**		
Course Code: **B010801T**	Course Title: **Relativistic Mechanics & Classical Electrodynamics**	

Course Objectives and Outcomes

Course Objective: To provide a systematic and core knowledge of Relativistic Mechanics and Classical Electrodynamics based on firm theoretical foundation with particular emphasis on Relativistic generalization of the subject matter. To produce academic teachers and researchers of highest calibre for the future.

Course Outcomes: The students will be able to develop a knowledge and understanding of the concepts and covariant formulation of the underlying principles of the course.

Credits: **4**	Course: **Major (Compulsory)**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Review of basic concepts of STR and Tensors:** Minkowski space, event, world line, light cone, concept of invariant interval, Lorentz transformation as 4-vector transformation, metric tensor, symmetric and anti-symmetric tensors, 4-scalors, 4-vectors, 4-tensors, 4-displacement, 4-velocity and acceleration; 4-momentum and 4-force, 4- potential, proper time, covariant form of equation of motion.	08
II	**Dynamics of Charged Particles in Electromagnetic Fields:** Motion in uniform static E-field, uniform static B- field, crossed E- and B- fields, particle drifts (velocity and curvature) in non-uniform static B- field.	06
III	**Field, Potential and Radiation from Moving Charges:** Retarded Potential and Lienard-Wiechert potentials, fields due to a charge moving with uniform velocity; fields due to an accelerated charge; near and far zone fields, multipole radiation, dipole and quadrupole radiation, Larmor's formula and its relativistic generalisation (Lienard's formula), power radiated by a point charge, angular distribution of radiated power for linearly and circularly accelerated charges, Bremsstrahlung, Synchrotron radiation, Cherenkov radiation, reaction force of radiation, electromagnetic mass of the electron, radiative damping, scattering by free charges.	16

IV	**Relativistic Formulation of Electrodynamics:** Four dimensional formulation of Euler-Lagrange equation of motion, covariance of Lorentz force equation and the equation of motion of a charged particle in an electromagnetic field, electromagnetic 4-potential and gauge invariance, energy-momentum tensor and the conservation laws for the electromagnetic field, electromagnetic field tensor in four dimensions, transformation properties of electric and magnetic fields, invariants of electromagnetic fields, dual filed tensor, the equation of continuity, wave equation for vector and scalar potential and solution, relativistic particle in electromagnetic field, four dimensional formulation of Maxwell's equations.	**16**
V	**Lagrangian Formulation of Electrodynamics:** Lagrangian and Hamiltonian for a free relativistic particle, Lagrangian for a charged particle in an electromagnetic field, for a free electromagnetic field, for interacting charged particles and fields (minimal coupling prescription), action of a relativistic charged particle, energy-momentum tensor and related conservation laws, generalised momentum and Hamilton equation of motion.	**14**

Suggested Readings

[1] J.D. Jackson, Classical Electrodynamics (Wiley, 1998).
[2] W.K.H. Panofsky, M. Phillips, Classical Electricity and Magnetism (Dover Publications, 2012).
[3] L.D. Landau, E.M. Lifshitz, Classical theory of fields (Butterworth-Heinemann, 1987).
[4] D. J. Griffiths, Introduction to Electrodynamics (Cambridge University Press, 2017).

Course Books published in Hindi may be prescribed by the Universities.

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as a Major (Compulsory) by the students of following subjects
M. Sc.-I, Sem-II
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test/Quiz/Assignment /Seminar 05 marks for Class Interaction
Course Prerequisites
Passed Semester -I (M Sc. Physics)
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
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P.G. PHYSICS

Programme/Class: **M. Sc.**	Year: **First**	Semester: **VIII**
Subject: **Physics**		
Course Code: **B010802T**	Course Title: **Statistical Physics**	

Course Objectives and Outcomes

Course Objective: This course makes the students realize the beauty of Statistical Mechanics, which predicts the bulk properties of matter without considering properties of individual constituents from first principle.

Course Outcome: After completing this course, the students will be able to:

1. derive the familiar gas law by using Maxwell Boltzman statistics.
2. understand the distinction between classical and the quantum systems.
3. understand how specific heats of solids approaches the value of 3R near room temperature in both Einstein & Debye's models.
4. learn how energies fluctuate with particle number.

Credits: **4**	Course: **Core (Compulsory)**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Ensemble Theory:** Micro canonical, Canonical and Grand Canonical ensembles and their partition functions, Partition function for mono atomic and Diatomic gases, Relationship between Helmholtz function and partition function, Entropy, Definitions of Temperature, Pressure and Chemical Potential, Gibbs Paradox.	14
II	**The Heat Capacity of Solids:** Dulong-Petit Law, Einstein's & Debye's theory of specific heats of solids, Comparison with experimental results.	8
III	**The Perfect Classical Gas:** The Definition of perfect Classical gas, Translational, rotational and vibrational partition functions, Expressions for Helmholtz free energy and chemical potential, Validity condition for classical regime, Equation of State of perfect classical gas.	12

IV	**The Perfect Quantum Gas:** Postulates of quantum Statistics, Partition function of a perfect quantum gas, Ideal Fermi Gas, Fermi energy, Fermi momentum, Pressure and chemical potential at absolute zero, Application to degenerate electron gas/metals, relativistic electron gas, Ideal Bose gas, Bose-Einstein condensation, Partition function and free energy for a photon gas, Derivations of Planck's Law, Wein's Law, Stefan-Boltzmann law and equation of State of black body radiation.	**14**
V	**Phase-transition and Fluctuations** First and second-order phase-transitions, The Bragg-William's approximations, Ising and Heisenberg models in one dimension, Fluctuations in Ensembles, concentration fluctuations in classical and quantum gases, Random Walk, Langevin Theory of Brownian motion.	**12**

Suggested Readings

1. Statistical Physics 2nd Edition. F. Mandl ELBS JohnWiley1988 published in Great Britain.
2. Statistical Physics PartI, Landau and Lifshitz, Pergamon Press Oxford.
3. Introduction to Statistical Physics Silvio RA Salinas, Springer.
4. Statistical Mechanics, B.K. Agarwal, Melvin Eisner, 3rd edition, New Age.
5. Fundamentals of Statistical Mechanics, B.B. Laud, New Age.

Course Books published in Hindi may be prescribed by the Universities.

P.G. PHYSICS

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as an Elective by the students of following subjects
M.Sc. Physics-I, Sem-I
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar 05 marks for Class Interaction
Course Prerequisites
M.Sc. Physics-I, Sem-I
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
• Other digital platforms /web links and Equivalent online courses may be suggested /added to the respective lists by individual Universities. • In End-semester University Examination, equal weightage should be given to each unit 1-V while framing the questions.

P.G. PHYSICS

Programme/Class: **M.Sc**	Year: **First**	Semester: **VIII**
Subject: **Physics**		
Course Code: **B010803T**	Course Title: **Plasma Physics**	

Course Objectives and Outcomes

Course Objectives: This course takes into account the fourth state of matter called the plasma.

Course Outcome: The students will come to know the role of plasma particularly in bringing nuclear fusion reaction into practical reality.

Credits: **4**	Course: **Optional**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Plasma State & its Properties:** Elementary ideas of plasma state of matter Existence of plasma, Definition of Plasma, Debye shielding 1D and 3D, Criteria for plasma, Applications of Plasma Physics (in brief), Motion of charge, Particles in uniform E&B fields, non-uniform fields, drifting motion, electrostatic and magnetostatic lenses, Adiabatic invariants, Plasma confinements (Pinch effect, Mirror confinement, Van Allen Belts)	**20**
II	**Hydrodynamical Description of Plasma:** Hydroynamical description, Equation of magneto-hydrodynamics, High frequency plasma oscillations, Short wavelength limit and Debye-screening distance	**10**
III	**Kinetic Theory of Plasma** The meaning of f(v), Equations of kinetic theory ,Boltzmann-Vlasov equation, Landau damping, Collision damping	**10**

IV	**Wave Phenomenon in Magneto-Plasma** Electromagnetic waves perpendicular to B0,Phase velocity, Polarization, Cut-off and resonances, Electromagnetic waves parallel to B0, Magnetosonic and Alfven wave	**10**
V	**Introduction to Controlled Fusion** The problem of controlled fusion, Magnetic confinements such as Toruses, Mirrors, Pinches, Laser Fusion, Plasma heating, Fusion Technology	**10**

Suggested Readings

1. Introduction to Plasma Physics by F. F. Chen (Plenum Press, New York).
2. Plasma Physics by A. Bittencourt,

Course Books published in Hindi may be prescribed by the Universities.

P.G. PHYSICS

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as an Elective by the students of following subjects
M.Sc. Physics-I, Sem-II
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar 05 marks for Class Interaction
Course Prerequisites
M.Sc. Physics-I, Sem-I
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
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Programme/Class: **M.Sc**	Year: **First**	Semester: **VIII**
Subject: **Physics**		
Course Code: **B010805T**	Course Title: **Introduction to Modern Physics**	

Course Objectives and Outcomes

Course Objective: The primary goal to design this course is to provide the students valuable information about the various naturally occurring phenomena that were not clearly understood. To explain these concepts and theories through a wider range of current applications and examples.

Course Outcome: After completing this course the students shall:

1. understand the particle aspect of radiation and wave aspect of material particles such as photoelectric and Compton effects, de-Broglie waves, Phase and group velocities.
2. get the knowledge of how atoms interact and how their energies change under electric and magnetic fields.
3. how quantum mechanical treatments of solids leads to the value of specific heat predicted by Dulong-Petit law.
4. get the knowledge of mediating quanta of fundamental forces.
5. gain the information and knowledge of how LASERS have enabled us to restudy and investigate Raman Scattering with greater precision.

Credits: **4**	Course: **Optional**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Particle Aspect of Radiation:** Photoelectric effect, Quantum interpretation, Work function, X–ray production and Bremsstrahlung, Compton effect, Pair production and annihilation. **Wave Aspect of Material Particles:** de-Broglie waves, Experimental verification of matter waves, Wave packet, Phase and group velocities. Schrödinger equation, Particle in a box, Wave functions of a simple harmonic oscillator, Wave functions of H- atom.	12
II	**Many Electron Atoms:** Constants of motion in a classical system, Quantization of orbital angular momentum and its component, Normal and Anomalous Zeeman effect, Zeeman effect in sodium, concept of spin of an electron, Spin–orbit interaction coupling, Spectroscopic notation of energy states. JJ coupling, Stern-Gerlach experiment, characteristic and continuous X-ray Spectra, Moseley Law.	14

III	**Quantum Theory of Specific Heat of Solids:** Phonon, density of states, Debye theory of specific heat due to lattice vibrations, Debye temperature, Free electron theory of metals, Fermi energy, Fermi velocity and Fermi temperature, Electronic contribution to Specific heat of metals.	**10**
IV	**Introduction to Nuclear and Particle Physics:** A survey of nuclear properties (Nuclear sizes, mass, Binding energy, Density, Electric quadrupole moment etc.), Brief discussion on achievements of Liquid drop Model, Prediction of magic numbers, Review of shell model and prediction of spin and parity of nuclei, Alpha, beta and gamma decay and selection rules. Nuclear fission, fusion, and applications, Elementary particles and conservation laws, Fundamental interactions, Quark flavor, Introduction to particle accelerators and detectors (LHC, RHIC, Scintillation and Cerenkov detectors).	**12**
V	**Lasers, Molecular Spectra and Raman Effect:** Working Principle of Laser, Concept of population inversion, Optical pumping, semiconductor Laser diode and applications, Introduction to molecular spectra, Types of molecular energy states and associated spectra, Types of spectra, Theory of the origin of pure rotational and vibrational-rotational spectra of a molecule, Salient features of Raman effect and its experimental study.	**10**

Suggested Readings

1. T. Weinder Robert L. Sells, Allyn and Bacon. Elementary Modern Physics-3rd edition-Richard.
2. Eisberg & Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, 2nd Editon-Wiley-1985.
3. A. Beiser, Perspectives of Modern Physics 3rd edition.
4. Littlefield & Thorley, Atomic and Nuclear Physics 2nd edition.

Course Books published in Hindi may be prescribed by the Universities.

P.G. PHYSICS

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as an Optional by the students of following subjects
M.Sc. Physics-I, Sem-II
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar 05 marks for Class Interaction
Course Prerequisites
M.Sc. Physics-I, Sem-I
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
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Programme/Class: **M.Sc**	Year: **First**	Semester: **VIII**
Subject: **Physics**		
Course Code: **B010806T**	Course Title: **Quantum Mechanics-II**	

Course Objectives and Outcomes

Course Objective:

1. To acquire knowledge of Approximation Method for Stationary and Non-Stationary States.
2. To have the knowledge of Elementary Theory of Scattering, Semi-Classical Theory of Radiation, & Relativistic Quantum Mechanics

Course Outcomes:

1. Understand the significance of Approximation Method for Stationary and Non-Stationary States.
3. The topics covered in the syllabus show an understanding of Elementary Theory of Scattering, Semi-Classical Theory of Radiation, & Relativistic Quantum Mechanics
2. After completion of the course, students have knowledge and ability to apply Quantum mechanics to particles and fields

Credits: **4**	Course: **Optional**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Approximation Methods for Stationary States:** Time-Independent Perturbation Theory, Perturbation Theory of Non-Degenerate States: First and Second Order Correction. Perturbation Theory of Charged Oscillator in an Electric Field, The Stark Effect, Degenerate Perturbation Theory, Fine Structure and Zeeman Effect, Variational Method, WKB Approximation Method.	15
II	**Time-Dependent Perturbation Theory:** The Picture of Quantum Mechanics: Schrodinger, Heisenberg, and interaction Pictures, Heisenberg Equation of Motion. Time –Dependent Perturbation Theory: Transition Probability. Fermi Golden Rule. Adiabatic and Sudden Approximations.	7
III	**Elementary Theory of Scattering:** The Differential and Total Cross-section. The Lippmann-Schwinger Equation. The Born Approximation. Partial Wave Analysis. Phase Shift.	7

IV	**Semi-Classical Theory of Radiation:** Absorption and Induced Emission: Transition Probability, Interpretation in Terms of absorption and Emission, Electric Dipole Transition, Forbidden Transition. Spontaneous Emission: Classical Radiation Field, Asymptotic Form. Radiated Energy. Dipole Radiation. Line Breadth	**8**
V	**Relativistic Quantum Mechanics:** The Klein-Gordon Equation: Plane Wave Solutions, Charge and Current Densities, Interaction with Electromagnetic Fields, Non-relativistic Limit. The Dirac Equation: Dirac's Relativistic Hamiltonian. Position Probability Density. Plane Wave Solution of Dirac Equation. The Probability Density. Plane Wave Solution of Dirac Equation. The Spin of Dirac Particle. Significance of Negative Energy States. The Spin Orbit Energy.	**15**

Suggested Readings

1. Quantum Mechanics: Concepts and Applications: N. Zettili
2. Quantum Mechanics: L. I. Schiff
3. Quantum Mechanics : P. M. Mathews and K. Venkatesan
4. Modern Quantum Mechanics: J. J. Sakurai
5. Relativistic Quantum Mechanics: J.D. Bjorken and S.D. Drell.
6. Principles of Quantum Mechanics: P. A. M. Dirac

Course Books published in Hindi may be prescribed by the Universities.

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as an Optional by the students of following subjects
M.Sc. Physics-I, Sem-II
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar 05 marks for Class Interaction
Course Prerequisites
M.Sc. Physics-I, Sem-I
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
• Other digital platforms /web links and Equivalent online courses may be suggested /added to the respective lists by individual Universities. • In End-semester University Examination, equal weightage should be given to each unit 1-V while framing the questions.

Programme/Class: **M. Sc.**	Year: **First**	Semester: **VIII**
Subject: **Physics**		
Course Code: **B010807P**	Course Title: **Electronics Lab**	

Course Objective & Outcomes

Course Objective: The experiments are an essential and inseparable part of Physics Course. The validity of various Laws and observations are tested through experiments in the Lab.

Course Outcomes: The results of an experiment (in agreement/deviated from the established pattern) enable the students to recognise the faults/errors in his approach and encourages to repeat the experiment with an improved approach.

Credits:**01**	Course: **Core (Compulsory)**
Max. Marks: **25+75** One Practical: 40 Marks Record: 10 Marks Viva-Voce: 20 Marks Attendance: 05 Marks.	Min. Passing Marks:

Total No. of Lectures-Tutorials-**Practical (in hours per week)**: L-T-P: 0-0-**2**

Topics	**No. of Hours**
1. Study of half – wave and full wave rectifiers and measurement of ripple factor. 2. Study of Timer 555 in astable and monostable modes. 3. Operational amplifiers: Measurement of Input bias current and gain in inverting and non – inverting modes. 4. Operational amplifiers as summing amplifier, Integrator and differentator. 5. Study of (a) Zener Regulated (b) Pass. transistor regulated and (c) regulated power supply and measurement of percentage regulation. 6. Triggering characteristics of SCR. 7. Study of wave shaping circuits – clippers and clampers. 8. Study of multivibrators. 9. Emitter Follower. 10. Study of voltage and current regulation by VR tube (OA2)	**30**

Note:

- The student has to do a minimum of six experiments from the given list.
- In the practical examination the student will be asked to perform one experiment of two hours duration.

Suggested Readings

1. Electronic Principles – A. Malvino, D.J. Bates 7th ed TMH, N. Delhi.
2. Microelectronic Circuit and Devices – Mark N. Horenstein, Pearson 2nd ed.
3. Fundamentals of Analog Circuits – Floyd, Buchla 2nd ed, Pearson – 2017.
4. Digital System – R.J. Tocci, PHI 6th ed, 2000.
5. Digital Logic and Computer Design – M. Morris Mano, PHI, Delhi 1996.
6. Integrated Electronics: Analog and Digital circuits and Systems, J. Millman, C. C. Halkias, TMH, Edition 1991.

Course Books published in Hindi may be prescribed by the Universities.

P.G. PHYSICS

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as a Major (Core) by the students of following subjects
M.Sc.-I, Sem-II
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar/ 05 marks for Class Interaction
Course Prerequisites
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
• Other digital platforms /web links and Equivalent online courses may be suggested /added to the respective lists by individual Universities. • In End-semester University Examination, equal weightage should be given to each unit 1-V while framing the questions.

Programme/Class: **M.Sc.**	Year: **First**	Semester: **IX**
Subject: **Physics**		
Course Code: **B010901T**	Course Title: **Fundamentals of Nuclear and Particle Physics**	

Course Objectives and Outcomes

Course Objective:

This course discusses the fundamental concepts of nuclear, particle, cosmic rays and comprehension of the cosmos and their recent trends including neutrinos.

Course Outcomes:

After the completion of this course, students will be able to:

1. develop an understanding of essential nuclear characteristics and associated nuclear models, nuclear decays and nuclear reactions.
2. learn about the basic building blocks of matter and the fundamental forces of nature, particle accelerators and detectors.
3. gain ideas about properties of cosmic rays.

Credits: **4**	Course: **Major (Compulsory)**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Properties of Nuclei and Nuclear Models:** Review of some important properties of nuclei, Nuclear (radius & its measurement using muonic X-rays and α–scattering, Magnetic dipole moment, Electric quadrupole moment and density), Nuclear magnetic resonance. Qualitative idea about liquid drop model, Nuclear shell model, Concept of magic numbers, Prediction of energy levels in harmonic oscillator potential, Spin-orbit coupling, Prediction of ground state spin and parity of nucleus. Q-values and concept of nuclear cross-section, Compound nuclear theory, Briet-Wigner's dispersion single level formula, Concept of direct, Pickup and stripping reactions.	14
II	**Radioactive Decays** Review of α, β, & γ decay, Selection rules, Gamow theory of alpha decay, Fermi theory of Beta-decay, Parity Non-Conservation in β decay, Wu's Experiment, Curie plots & Comparative half-lives, Allowed & Forbidden Transitions, Multipolarity of gamma transition, Brief idea of internal conversion of gamma rays.	10

III	**Introduction to Elementary Particle Physics:** Types of fundamental forces, Classification of elementary particles and their quantum numbers (Hyper charge, Isospin, Color), Quark flavors.Quark model of hadrons, Baryon decuplet and octet, Charge(C), Parity (P) & Time Reversal (T) invariance, CPT Theorem, Parity non- conservation in weak interactions, Strangeness Oscillations, K_L- K_S mass difference & charge-parity (CP) non-conservation in K^o decays, Brief description of neutrinos, its mass, Introduction to standard model of particle physics.	**14**
IV	**Two Body Problem:** Investigation of nature of nuclear forces from simple two body problems. Ground state of a Deuteron, S and D state, neutron–proton and proton–proton scattering, central and noncentral forces. Spin dependence of nuclear forces, exchange forces.	**10**
V	**Cosmic Rays, Particle Accelerators and Detectors:** Properties of primary cosmic ray (Energy & Charge Spectrum) & idea of origin of secondary cosmic rays, Cascade &extensive showers. Need for accelerator of charged particles, Classification of accelerators, Proton Synchrotron, Betatron, Introduction of modern Colliders (LHC and RHIC), Cherenkov Detector and qualitative discussion on Resistive Plate Chambers.	**12**

Suggested Readings

1- Halliday, D.:Introductory Nuclear Physics (JohnWiley)
2- Roy, R.R. & Nigam, B.P.: Nuclear Physics (JohnWiley).
3- Enge, H.A.:Introduction to Nuclear Physics (Addison Wesley)
4- Evans, R.D.:Atomic Nucleus (McGraw Hill)
5- Ghosal, S.N.:Atomic & Nuclear Physics (S. Chand Company Ltd.)
6- Segre, E.: Nuclei &Particles (2nd Ed). (Benjamin/Cummings).
7- Perkins. D.H.:Introduction to High Energy Physics(Addison Wesley).
8- Wong, S. S. M. Introductory Nuclear Physics Second Edition (Wiley VCH)
9- Nuclear & Particle Physics: W. Burcham & M. Jobes.
10- Harynes, R.C.: Introduction to Space Science (JohnWiley).
11- Karttunen, H.Kroger, P. Oja, H. Poutenon. Mand Donner K.J. Fundamental of Astronomy (Springer-Verlag).
12- Bhatia V.B. Text Book of Astronomy & Astrophysics with Elements of Cosmology. (Narosa Publishing House).
13- Ryan S.G. & Norton, A.J. Stellar Evolution of Nuclear synthesis (Cambridge).
14- Rossi, B. Cosmic rays (George Allenand Unwin).

Course Books published in Hindi may be prescribed by the Universities.

P.G. PHYSICS

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as a Major (Compulsory) by the students of following subjects
M.Sc. Physics-I, Sem-III
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar 05 marks for Class Interaction
Course Prerequisites
Passed M.Sc. Physics-I, Sem-II
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
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Programme/Class: **M.Sc**	Year: **Second**	Semester: **IX**
Subject: **Physics**		
Course Code: **B010902T**	Course Title: **Solid State Physics**	

Course Objectives and Outcomes

Course Objective: To provide the information about how the different properties of matter are determined by their structure.

Course Outcome: The students will come to know various applications of solid state of matter and job opportunities.

Credits: **4**	Course: **Major (Compulsory)**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Crystal Binding And Structure:** Space lattice and basis, Lattice types, Miller indices, Important crystal structure (NaCl, CsCl, ZnS, graphite and diamonds), Reciprocal Lattice and Brillouin Zone,Elementary idea of crystal structure analysis and crystal defects	10
II	**Lattice Dynamics And Thermal Properties** Lattice vibrations of mono and diatomic chains, Infrared absorption of ionic crystals, quantization of lattice vibration and phonon, Einstein and Debye theories of specific heat, Anharmonicity and Thermal expansion	9
III	**Free Energy And Energy Band Theories** Density of states, Fermi and mean energy at zero and finite temperatures, specific heat and origin of energy bands, Bloch theorem, Kroning Penny model, concept of electron dynamics in crystalline lattice, Tight binding approximation	10
IV	**Magnetic Properties** Diamagnetism, Paramagnetism, Ferromagnetism: Magnetic domains, Basic features and their explanation by molecular field theory, Heisenberg explanation of internal magnetic field, spin wave theory and magnons, Basic features and Neel's two sub-lattice models of antiferro and ferrimagnetic materials.	10

V	**Optical Properties** Optical reflectance, Kramers-Kronig relations; Conductivity and dielectric function of collision electron gas	7

Suggested Readings

1. Solid State Physics by C Kittel
2. Solid State Physics by J.D. Patterson and B.C. Bailey
3. Elementary Solid State Physic by Ali Omar
4. Solid State Physics by A J Dekkar
5. Solid State Physics by F W Ashckroft and N D Mermin

Course Books published in Hindi may be prescribed by the Universities.

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as a Major (Compulsory) by the students of following subjects
M.Sc. Physics-I, Sem-III
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar 05 marks for Class Interaction
Course Prerequisites
Passed M.Sc. Physics-I, Sem-II
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
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Programme/Class: **M. Sc.**	Year: **Second**	Semester: **IX**
Subject: **Physics**		
Course Code: **B010903T**	Course Title: **Classical Field Theory**	

Course Objectives and Outcomes

Course Objective: To provide a course of the highest academic quality with deeper knowledge and understanding of Classical Field Theory in a highly challenging but supportive and cooperative atmosphere so as to produce an efficient and competent fellow.

Course Outcomes: The students will be able to develop an understanding of the concepts and principles of Classical Field Theory.

Credits: **4**	Course: **Major Subject (Optional)**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Conceptualisation and Governing Equations of Motion:** General concept and formalism of a field, classical field, Lagrangian for a particle and Lagrangian density for a field, Hamiltonian for a particle and Hamiltonian density for a field, canonical or generalised momentum of a field, energy and momentum of a field, Lagrangian density as sum of kinetic and interaction terms, , basic idea of calculus of variations, Principle of Least action, Hamilton's variational principle, condition for equation of motion, Lagrangian and Hamiltonian formulation of fields.	15
II	**Symmetry and Conservation Laws:** Symmetry and conservation laws, Noether's theorem, conserved current, Galilean and Lorentz invariance, time reversal, space reflection; field transformations, Covariant formulation of fields, free scalar field, vector fields, the 4-vector potential, antisymmetric field tensor, Lagrangian density for free vector field, particle and field energy-momentum conservation.	15
III	**Radiation Field:** Classical Maxwell field, charged particle interaction and the Lorentz force, field equations with particles; gauge invariance, Lorentz gauge, charge conservation, energy and momentum of electromagnetic field, angular momentum of electromagnetic field, Maxwell stress tensor for electromagnetic field, potentials and gauge symmetry, canonical quantisation using radiation gauge, discussion of ambiguities in quantisation and their removal and Lorentz gauge quantisation. Dirac spinor field and its quantisation (anti-commutation relations).	15

IV	**Applications:** Interaction of radiation with matter (spontaneous and stimulated emission, absorption), Plancks Law, Kramer-Heisenberg Formula, Coherent Raman scattering, Theory of Line width, photo electric effect, non-relativistic theory of Lamb shift.	**15**

Suggested Readings

[1] L. Landau, E.M. Lifschitz, Classical Theory of Fields (Butterworth Heinmann, 1975).
[2] F. E. Low, Classical Field Theory (Wiley, 1997).
[3] J.D. Jackson, Classical Electrodynamics, Wiley, 1998.
[4] H. Goldstein, C. Poole, J. Safko, Classical Mechanics (Pearson, 2001).
[5] J. D. Bjorken, S. D. Drell, Relativistic Quantum Fields, Vol-I & Vol-II, (McGraw Hill 1964, 1978)
[6] J. J. Sakurai, Advanced Quantum Mechanics (Pearson Education, 1998).

Course Books published in Hindi may be prescribed by the Universities.

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as an Optional by the students of following subjects
M. Sc.Physics-II, Sem-III
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test/Quiz/Assignment /Seminar 05 marks for Class Interaction
Course Prerequisites
Passed Semester-II in Physics
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
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P.G. PHYSICS

Programme/Class: **M. Sc.**	Year: **Second**	Semester: **IX**
Subject: **Physics**		
Course Code: **B010904T**	Course Title: **Electronics-II**	

Course Objectives and Outcomes

Course Objective:
This course makes student aware of microwaves, antennas, transmission cables and optical fibres. Antennas are the chief devices that transmit and receive the signals.

Course Outcomes:
After learning this course, the students will be able to:
(i) get an idea of various tube based and semiconductor based sources of microwaves.
(ii) understand the principle of velocity modulation and bunching.
(iii) know how an infinitesimal current element becomes source of Electromagnet radiation.
(iv) understand how optical fibres carry light from one end to the other.
(v) understand the behaviour of parallel wire and coaxial cables.

Credits: **4**	Course: **Major (Compulsory)**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Microwaves:** Generation problems, Limitations of conventional vacuum triodes, tetrodes and pentodes, MW sources, Two cavity Klystron, principle of velocity modulation and bunching, output power and Maximum efficiency, Reflex Klystron, power output and efficiency, operating principle of a TWT, cylindrical Magnetron. Hull cut off voltage equation, Gunn Oscillator, Tunnel diode.	15
II	**Antenna:** Review of scalar and vector potentials, retarded vector potential and spherical polar coordinates, Radiation fields of a current element, Average radiated power and radiation resistance, Half – wave antenna radiating in space, Antenna Gain, Antenna Array, Broadside and End – Fire array, Effective length and effective area of antenna. Relationship between effective length, effective area and Gain.	15
III	**Optical Fibre:** Optical fibre structure, Light propagation, Numerical aperture acceptance angle, step and graded index fibre, Losses in optical fibre, Dispersion in an optical fibre, Light sources for optical fibre, Fibre – LED coupling, Optical fibre communication system.	10

IV	**Transmission Lines:** General Transmission Line equations, wave characteristics on an infinite Transmission Line, characteristic impedance, Transmission line parameters, wave characteristics on finite transmission Line, transmission line as circuit element, Lines with resistive and arbitrary terminations, smith chart applications, Impedance matching.	**10**
V	**Microprocessors:** Introduction to 8085, microprocessor architecture, Instructions and timing, assembly language programming, Stack and subroutines. Interfacing with IC 8255 and memory.	**10**

Suggested Readings

1. Microwave Devices and Circuits 3rd edition – Samuel Y. Liao Pearson – 2003
2. Electronic Communication Systems, Fourth Edition – Kennedy. Davis TMH edition 1999.
3. Networks, Lines and Fields, J. D. Ryder, PHI
4. Optical Fibres and Fibre Optic Communication Systems – Subir Kumar Sarkar, S. Chand 2003.
5. Field & wave Electromagnetics 2nd Edition – D.K. Cheng, Pearson Education.

Course Books published in Hindi may be prescribed by the Universities.

P.G. PHYSICS

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as an Optional by the students of following subjects
M.Sc. Physics-II, Sem-III
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar 05 marks for Class Interaction
Course Prerequisites
Passed M.Sc. Physics-I, Sem-II
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
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Programme/Class: **M.Sc**	Year: **Second**	Semester: **IX**
Subject: **Physics**		
Course Code: **B010905T**	Course Title: **Atomic and Molecular Physics**	

Course Objectives and Outcomes

Course Objectives:

This course puts emphasis on atomic, molecular, electronic, Raman and X-ray spectroscopy.

Course Outcome:

After completing this course, the students will be able to get information about energy levels of atoms and molecules and the transitions between them.

Credits: **4**	Course: **Optional**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Atomic Spectroscopy:** Vector Atom model , Atomic structure, electronic angular momentum, many electron atoms, angular momentum of many electron atoms ,L S coupling & J J coupling, effect of electric & magnetic field on atoms and molecules; Zeeman effect, Paschen Back effect and stark effect	15
II	**Molecular Spectroscopy of molecules:** IR and Raman spectra of rigid rotator and harmonic oscillator, IR and Raman spectra of non-rigid rotator, anharmonic oscillator and vibrating rotator, Isotope effect in rotation and vibration spectra.	15
III	**Electronic Spectroscopy of molecules:** Electronic energy and total energy ,Vibrational Analysis of band systems, Deslander"s table, Progressions & sequences, Rotational fine structure and P, Q and R Branches, Fortrat Diagram, , Franck Condon Principle and its quantum mechanical formulation	10

IV	**Raman Spectroscopy:** Raman Spectroscopy – Raman effect, Rotational Raman Spectra, vibrational Raman Spectra, structure determination using Raman spectroscopy	**10**
V	**X-ray Spectroscopy and Spin Spectroscopy:** Electron spectroscopy of molecules. Spin resonance spectroscopy, NMR.	**10**

Suggested Readings

1. Molecular Structure & Spectroscopy by G. Aruldas
2. Fundamentals of Molecular Spectroscopy by C. N. Banwell & E.M. McCash
3. Introduction to atomic spectra by H. E. White
4. Molecular Spectra and Molecular Structure by G. Herzberg (Dover Publication, London).
5. Introduction to Molecular Spectroscopy by G.M.Barrow

Course Books published in Hindi may be prescribed by the Universities.

P.G. PHYSICS

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as an Optional by the students of following subjects
M.Sc. Physics-II, Sem-III
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar 05 marks for Class Interaction
Course Prerequisites
Passed M.Sc. Physics-I, Sem-II
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
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Programme/Class: **M.Sc**	Year: **Second**	Semester: **IX**
Subject: **Physics**		
Course Code: **B010906T**	Course Title: **Experimental Techniques**	

Course Objectives and Outcomes

Course Objectives:

This course focuses on pumps, gauges, and techniques employed for morphological study of various materials.

Course outcomes:

After studying this course the students will be able to distinguish between the techniques and tools employed for investigating various properties/characteristics of materials.

Credits: **4**	Course: **Major (Compulsory)**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Vacuum Techniques:** Units and basic definitions, Roughing pumps, High vacuum Vacuum guages - Pirani gauge, Thermocouple gauge, penning guage (Cold cathode Ionization guage) and Hot filament ionization gauge.	9
II	**Thin film techniques:** Introduction, Fabrication of thin films, Technological Applications of thin films.	8
III	**Morphological study:** Scanning tunneling microscopy (STM), Atomic Force Microscopy (AFM),Scanning Electron microscope(SEM),Scanning Tunneling Spectroscopy(STS).	9

IV	**X- Ray Diffraction Technique:** Introduction, Lattice planes and Bragg's Law, Diffractometer - Instrumentation, Single crystal and Powder diffraction, Scherrer equation, Structure factor, Applications of XRD.	9
V	**Tools for maths and visualisation in Python (The numpy and pylab modules)** Numpy module:- Arrays and Matrices–creation of arrays and matrices (arange, linspace, zeros, ones, random, reshape, copying), Arithmetic Operations, cross product, dot product ,Data visualization- The Matplotlib, Module- Plotting graphs, Multiple plots, .Polar plots, Pie Charts, Plotting mathematical functions, Sine and other functions.	10

Suggested Readings

1. Scientific foundations of vacuum techniques by S. Dushman and J.M. Laffer.
2. Thin film technology by R. Berry, P.M. Hall and M.T. Harris.
3. Elements of X-ray diffraction by B.D. Cullity.
4. Introduction to Nanoscience & Technology by K.K.Chathopadhyay, A.N.Banerjee.
5. Advanced Experimental Techniques in Modern Physics by Muraleedhara Varier.
6. Core Python Programming by Wesley J Chun.
7. Numerical Methods in Engineering with Python by Jaan Kiusalaas.

Course Books published in Hindi may be prescribed by the Universities.

P.G. PHYSICS

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1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as an Optional by the students of following subjects
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Course Prerequisites
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Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
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This course can be opted as an Optional by the students of following subjects
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P.G. PHYSICS

Programme/Class: **M. Sc.**	Year: **Second**	Semester: **IX**
Subject: **Physics**		
Course Code: **B010907P**	Course Title: **General and Optics Lab**	

Course Objective & Outcomes

Course Objective: The experiments are an essential and inseparable part of Physics Course. The validity of various Laws and observations are tested through experiments in the Lab.

Course Outcomes: The results of an experiment (in agreement/deviated from the established pattern) enable the students to recognise the faults/errors in his approach and encourages to repeat the experiment with an improved approach.

Credits:**01**	Course: **Core (Compulsory)**
Max. Marks: **25+75** One Practical: 40 Marks Record: 10 Marks Viva-Voce: 20 Marks Attendance: 05 Marks.	Min. Passing Marks:

Total No. of Lectures-Tutorials-**Practical (in hours per week)**: L-T-P: 0-0-**2**

Topics	**No. of Hours**
1. Zeeman effect 2. Michelson interferometer 3. Franck – Hertz experiment 4. e/m by Thomson's method 5. Planck's constant by LED's. 6. Solar Trainer 7. V-I Characteristics of U.J.T. 8. Speed of sound by C.R.O 9. Design of Regulated Power Supply, Audio amplifier and alarm circuits. 10. Design of voltage Doubler, Tripler and quadrupler circuits. 11. Miscellaneous experiments on Bread Board and discrete electronic components. 12. Study of Lattice Dynamics 13. Study of combinational circuits. 14. Phase Shift Oscillator 15. G.M. Counter.	**30**

Note:

- The student has to do a minimum of six experiments from the given list.
- In the practical examination the student will be asked to perform one experiment of two hours duration.

Suggested Readings

1. Electronic Principles – A. Malvino, D.J. Bates 7th ed TMH, N. Delhi.
2. Microelectronic Circuit and Devices – Mark N. Horenstein, Pearson 2nd ed.
3. Fundamentals of Analog Circuits – Floyd, Buchla 2nd ed, Pearson – 2017.
4. Digital System – R.J. Tocci, PHI 6th ed, 2000.
5. Digital Logic and Computer Design – M. Morris Mano, PHI, Delhi 1996.
6. Integrated Electronics: Analog and Digital circuits and Systems, J. Millman, C. C. Halkias, TMH, Edition 1991.

Course Books published in Hindi may be prescribed by the Universities.

P.G. PHYSICS

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as a Major (Core) by the students of following subjects
M.Sc.-II, Sem-III
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar/ 05 marks for Class Interaction
Course Prerequisites
Passed M. Sc.-I, Sem-II
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
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Programme/Class: **M.Sc**	Year: **Second**	Semester: **X**
Subject: **Physics**		
Course Code: **B011001T**	Course Title: **Advanced Solid State Physics**	

Course Objectives and Outcomes

Course Objective:
This course lays emphasis on the various properties change due to structure and other external factors including electric field, temperature, etc.

Course Outcomes:
This class of materials will open the door for a number of opportunities especially in the field on nano-materials and technology.

Credits: **4**	Course: **Optional**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Energy bands and Charge carriers in Semiconductors:** Bonding forces and energy bands, direct and indirect band gap semiconductors, Effective mass of electrons and holes in quantum wells, the Fermi level, electron and hole concentrations at equilibrium, temperature dependence of carrier concentrations, electrical conductivity and mobility.	10
II	**Ferroelectric behaviour of Materials:** Ferro-electric crystals, Order-disorder type of Ferro-electrics, Properties of $BaTiO_3$, Polarisation catastrophe, Landau theory of Ferro-electric phase transitions, Ferro-electric domain, Anti-ferro-electricity, Piezo-electricity, Applications of Piezoelectric Crystals.	10
III	**Superconductivity:** Meissner effect, Type I and Type II superconductors, London equation and penetration of magnetic field, Cooper pairs and B C S Theory (qualitative treatment), Flux quantization, SQUID, DC and AC Josephson effects, High Tc Superconductors.	10

IV	**Luminiscence and Colour Centres:** Basic Theories and models of luminiscence, Phosphorescence, Thermo-luminiscence, Electro-luminiscence and Photo-conductivity, Colour centres.	**8**
V	**Nano Science and Technology:** Conceptual development of nano-science, Nano-science in nature, Size effect on properties of nano- structures, Concepts of 2D nano-structures (quantum wells), 1D nano-structures (quantum wires) 0D nanostructures (quantum dots).	**7**

Suggested Readings

1. Solid State Physics: Structure and Properties of Materials by A. M. Wahab (Narosa Publishing House, India) 2nd Edition 2005
2. Elements of Solid State Physics (second Edition) by J. P. Srivatsava
3. Introduction to nano : basics to nanoscience and nanotechnology by Sengupta, Amretashis et.al, Springer, 2015.
4. Solid State Physics by Ashcroft & Mermin
5. Solid State Physics BY A.J.Dekker
6. Solid State Physics by C. Kittel

Course Books published in Hindi may be prescribed by the Universities.

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as a Optional by the students of following subjects
M.Sc. Physics-II, Sem-IV
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar 05 marks for Class Interaction
Course Prerequisites
Passed M.Sc.-II, Sem-III
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
• Other digital platforms /web links and Equivalent online courses may be suggested /added to the respective lists by individual Universities. • In End-semester University Examination, equal weightage should be given to each unit 1-V while framing the questions.

Programme /Class: **M. Sc.**	Year: **Second**	Semester: **X**
Subject: **Physics**		
Course Code: **B011002T**	Course Title: **Quantum Field Theory & Quantum Electrodynamics**	

Course Objectives and Outcomes

Course Objective: To develop a basic understanding of Quantum Field Theory which states the discrete nature of the fields- that is every field has its corresponding quantum of energy/particle. A novel and strange idea of quantum particle completely distinct from its counterpart as described in Classical field theory. A particular emphasis is done on Quantum Electrodynamics that describes the fundamental processes between light and matter via Feynman diagrams.

Course Outcomes: The students will be able to develop a better, simpler and broader understanding of the interactive processes taking place between fields and particles in terms of quantum-the force particles and matter particles.

Credits: **4**	Course: **Optional**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Basic conception of Fields and Particles:** Classical field, quantum field-as an approximation of classical field, coupled oscillators, normal modes, infinite degrees of freedom, continuum limits, particle as an excitation of field, number/Fock space representation and number operator , creation and annihilation operators, quantum particles and related equations of motion; Klein Gordon equation, free particle solution and interpretation, Dirac equation, free particle solution, negative energy states and antiparticle/hole theory, covariance of Dirac equation, concept of spin.	16
II	**Quantisation of Bosonic, Radiatin and Dirac free Fields:** Path integral formulation of quantisation, harmonic oscillator problem, Feynman diagrams in momentum and configuration space, canonical quantisation of Klein Gordon and charged scalar fields, radiation/electromagnetic fields, Dirac fields, canonical anti-commutation relations.	14

III	**Discrete Symmetries:** C, P and T symmetries of free scalar and charged scalar fields, radiation and Dirac fields, intrinsic parity, CPT transformation, invariance principles, Lorentz invariance of free field theory.	**08**
IV	**Basics of Gauge Theories:** Gauge invariance of charged scalar and Dirac fields, conservation of charge, local gauge invariance, minimal coupling and interaction of charged fields with Maxwell field anomalous magnetic moments and non-minimal Pauli coupling.	**08**
V	**Interacting Fields:** Interaction picture, time evolution operator, S-matrix and Schwinger Dyson expansion, time ordered product and Wicks theorem, Feynman diagrams for fundamental processes, lowest order calculations for Rutherford, Bhabha, Compton scattering, bremsstrahlung and Moller scattering, pair creation and annihilation, symmetry and supersymmetry, basic ideas on renormalisation.	**14**

Suggested Readings

1. L. Landau, E.M. Lifshitz, Classical Theory of Fields (Butterworth Heinmann, 1975).
2. V. B. Berestetskii, E. M. Lifshitz, L.P. Pitaevskii, Quantum Electrodynamics (Pergamon Press Ltd. England, 1982).
3. M.E. Perkins, D.V. Schroeder, An Introduction to Quantum Field Theory (Addison Wesley Publishing Company, 1996).
4. J.D. Bjorken and S.D. Drell, Relativistic Quantum Fields (McGraw Hill, 1964).
5. F. Mandl, G. Shaw, Quantum Field Theory (Wiley India, 2016).
6. C. Itzykson and J.B. Zuber, Quantum Field Theory (Tata McGraw-Hill, 1980).
7. A. Zee, Quantum Field Theory in a Nutshell (Princeton University Press, 2016).
8. Fundamentals of Quantum Electrodynamics by M. Imran Aziz, (Ayushman Publications, New Delhi.)

Course Books published in Hindi may be prescribed by the Universities.

P.G. PHYSICS

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as Optional by the students of following subjects
Passed Semester-III in Physics
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test/Quiz/Assignment /Seminar 05 marks for Class Interaction
Course Prerequisites
Passed Semester-III in Physics
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
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P.G. PHYSICS

Programme/Class: **M. Sc.**	Year: **Second**	Semester: **X**
Subject: **Physics**		
Course Code: **B011003T**	Course Title: **Electronic Communication**	

Course Objectives and Outcomes

Course Objective: The objective of this course is to make one understand the concept of electrical noise, its causes and effects on the electronic circuits. Also, to understand the techniques of transmission of information from one place to the other.

Course Outcomes: After completing this course the students will be able to:
(i) understand the concepts of generation and reception of information.
(ii) be familiar with the harmful effects of ever present "noise" on the working of electronic communication system.
(iii) grasp the concept of various techniques of digital transmission.
(iv) understand the relationship between the probability of message and the amount of information contained.

Credits: **4**	Course: **Optional**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Signals and Spectra:** Time domain and frequency domain representation of waveforms, Fourier Transform and its properties. Delta function and its application in communication. Spectra of sinusoid, rectangular and triangular pulses. Power spectral density, Line spectra and PSD of periodic wave forms, Band limited waveform and sampling theorem (Proof needed).	15
II	**Noise:** Thermal noise, shot noise, partition noise, series and parallel resistors as noise sources, mean square noise voltage in an RC circuit, available power, noise temperature, noise bandwidth, noise figure, noise figure of a Cascade. S/N ratio.	5
III	**Pulse Modulation:** Pulse Amplitude Modulation, Natural and Flat – top sampling, PAM spectrum, Aliasing effect, Pulse Code Modulation, Sampling, Quantization and Encoding, PCM transmitter and receiver, Transmission bandwidth of PCM, Effect of noise, 6dB rule, companding, A–law and μ–law companding, DPCM, Delta Modulation, Adaptive Delta Modulation, Pulse Time Modulation, PWM and PPM, generation and detection.	15

IV	**Digital Modulation Techniques:** ASK (OOK), Power spectral density and transmission bandwidth, Non coherent and coherent detection of OOK, BPSK generation and detection, spectrum of BPSK, PSD of BPSK, Differential Phase Shift keying, PSD of MSK, Generation and Reception of MSK.	15
V	**Information Theory:** Discrete messages, concept of amount of information, Average information, Entropy, Information Rate, Channel Capacity, Shannon Theorem, Discrete communication channels, Rate of information transmission over a discrete channel, capacity of a discrete memory less channel Shannon – Hartley Theorem and its implications.	10

Suggested Readings

1. Digital and Analog Communication Systems – Leon W.Couch 8th edition, Pearson.
2. Electronic Communication – Dennis Roddy. John Coolen 4th edition, PHI.
3. Principles of Communication Systems – Taub. Schilling, 2nd Edition, TMH 1991.
4. Digital and Analog Communication Systems – K Sam Shanmugam, Wiley.

Course Books published in Hindi may be prescribed by the Universities.

P.G. PHYSICS

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as Optional by the students of following subjects
Passed M. Sc.-II, Sem-IV
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test/Quiz/Assignment /Seminar 05 marks for Class Interaction
Course Prerequisites
Passed M. Sc.-II, Sem-III
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
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P.G. PHYSICS

Programme/Class: **M. Sc.**	Year: **Second**	Semester: **X**
Subject: **Physics**		
Course Code: **B011004T**	Course Title: **Liquid Crystal Physics**	

Course Objectives and Outcomes

Course Objectives: This course makes one awares of substances that are in crystalline states yet they flow.

Course Outcomes: The students will learn how LCD readouts function in wrist watches, calculator, multimeter, mobile phones screen etc.

Credits: **4**	Course: **Optional**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Classification of Liquid Crystals:** Introduction, classification of liquid crystals, thermotropic liquid crystals (rod like molecules), chirality in liquid crystals, nematic, cholesteric and smectic mesophases, polymorphism in thermotropic liquid crystals, polymer liquid crystals, applications of polymer liquid crystals	9
II	**Phase transitions in Liquid Crystals:** Melting of molecular crystals, distribution functions and order parameters, measurement of order parameters by X-ray diffraction. Nature of phase transitions and critical phenomena in liquid crystals, optical properties of cholesteric liquid crystals, the blue phases	9
III	**Liquid Crystals in Electric and Magnetic:** Fields Liquid crystals in electric and magnetic fields, magnetic coherence length, Freederick transitions, Effect of solid boundaries on liquid crystals	9
IV	**Other Type of Liquid Crystals:** Ferroelectric, Discotic and Lyotropic Liquid Crystals Ferroelectreic liquid crystals, applications of ferroelectric liquid crystals, discotic liquid crystals, discotic mesophase structures-the columnar liquid crystal, the discotic nematic phase. Lyotropic liquid crystals, constituents of lyotropic liquid crystals, structures of lyotropic liquid crystal phases, biological membranes	9

V	**Applications of Liquid Crystals:** Identification of Liquid Crystal Phases and Liquid Crystal Technology Identification of nematic, smectic and chiral liquid crystal phases by optical polarizing microscopy (Visual appearance and texture), liquid crystal displays, the twisted nematic liquid crystal displays, nematic liquid crystal displays, liquid crystal displays using polymers, applications of liquid crystals	**9**

Suggested Readings

1. Liquid Crystals by S.Chandrasekhar
2. Thermotropic Liquid Crystals by Vertogen and Jeu
3. The Physics of Liquid Crystals by de Geenes and Prost
4. Ferroelectric Liquid Crystals by Goodby et al.
5. Introduction to Liquid Crystals Chemistry and Physics by Peter J.Collings and Michael Hird.

Course Books published in Hindi may be prescribed by the Universities.

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as Optional by the students of following subjects
Passed M. Sc.-II, Sem-IV
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test/Quiz/Assignment /Seminar 05 marks for Class Interaction
Course Prerequisites
Passed M. Sc.-II, Sem-III
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
• Other digital platforms /web links and Equivalent online courses may be suggested /added to the respective lists by individual Universities. • **In End-semester University Examination, equal weightage should be given to each unit 1-V while framing the questions.**

Programme/Class: **M. Sc.**	Year: **Second**	Semester: **X**
Subject: **Physics**		
Course Code: **B011005T**	Course Title: **High Energy Physics**	

Course Objectives and Outcomes

Course Objectives:

The main purpose of high energy physics course also known as (particle physics) is to identify the most fundamental building components of matter and to comprehend their interactions. Further understanding and mechanism of multi-particle production can be acquired by attempting to comprehend what happens through the collisions of nuclei at relativistic energies, where new particles may be produced.

Course Outcomes:

After the completion of this elective course, students will have the following capability and skills:

1. Understand the concept and applications of natural units, fundamental interactions, Feynman diagrams, quark structure of hadrons and knowledge of experimental error analysis.
2. They can use the concept of relativistic kinematics in solving different problems and can explain the mechanism of multi-particle production in hadronic and ion-ion collisions.
3. Knowledge of different theoretical models of high energy nuclear collisions and can explain and describe the important physics scenario of modern detectors used in world class mega experiments such as ALICE, CMS CBM etc.

Credits: **4**	Course: **Optional**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Natural Units and Fundamental Interactions:** Introduction to natural units, Review of (classification of elementary particles and conservation laws, Quark model of hadrons), Eight fold way classification of mesons and baryons, Fundamental interactions and Feynman diagrams, The Standard model of particle physics and its shortcomings, Experimental errors, Random, Systematic and Statistical errors, Gaussian distribution.	**10**
II	**Relativistic Kinematics of High Energy Collisions:** Lorentz transformations for energy and momentum, four-vectors and invariants, Laboratory and Centre-of-momentum systems, calculation of energy, momentum and angle of particles produced in nuclear reactions in Lab and centre-of-momentum frames and their transformations and calculation of threshold energies for particle production, Mandelstam variables, Fermi Golden Rule, Brief discussion on Differential and total scattering cross sections, Lorentz invariant phase space.	**14**
III	**Discussion on Relativistic Hadron-Nucleus Interactions and Approaches to Study Correlation and Fluctuations:** Rapidity and pseudorapidity variables, Lab and CM-rapidity, Maximum and minimum rapidities, Pseudorapidity distribution in projectile, target and central fragmentation regions.	**14**

	Fluctuations and Correlations: Two-particle correlations, Short- and long-range multiplicity correlations, Entropy and its generalization, Shanon and Renyi Entropies, Characteristics of non-statistical fluctuations,Approaches to study non-statistical fluctuations using Intermittency (Scaled Factorial Moments),Multifractality (G-Moment and Takagi Moment) and Multifractal specific heat, Non-thermal phase transition.	
IV	**Models of High-Energy Nuclear Collisions, Formation of QGP and it's Signatures:** Participant-Spectator, Bjorken and Lund Model, Space-time evolution of heavy-ion collisions, Phase diagram of strongly interacting matter, De-confinement phase transition, Promising signals of Quark-Gluon Plasma formation, Dilepton production, Drell-Yan Process in nucleus-nucleus collision, Direct photon production, De-bye screening in the QGP, J/Ψ suppression in the QGP.	**10**
V	**Modern Detectors in High Energy Physics Experiments:** Fundamental features of detectors, Sensitivity, Energy resolution and fano factor, Detector efficiency and dead time, Multiwire and Drift Chambers, Ionization, drift and diffusion of charges in gases, Pulse formation and its shape in proportional counters, Multiwire proportional counter:-Working principle and Construction, Di-Muon Spectrometer of ALICE andQualitative discussion on(MuCh of CBM, Physics scenarios at RHIC and LHC energies).	**12**

Suggested Readings

1. Pilkuhn, H.: The Interactions of Hadrons
2. Martin, L.P.: High Energy Hadron Physics (John Willey)
3. Collins, P.D.B. & Martin, A.D.: Hadron Interactions (Adam Hingler)
4. Hagedorn, R. : Relativistics Kinematics (Benjamin)
5. Perkins, D.H. : Introduction to High Energy Physics (Addison Wesley)
6. Halzen, F. and Martin, A.: Quarks and Leptons (John-Wiley)
7. Wong, C.Y.: Introduction to High Energy Heavy Ion Collisions (World Scientific)
8. Ferbel, T. : Experimental Techniques in High Energy Physics (Addison Wesley)
9. Leo, W.R.: Techniques for Nuclear and Particle Physics Experiments (Narosa)
10. Kleinknecht, W.: Detectors for Particle Radiation (Cambridge)

Course Books published in Hindi may be prescribed by the Universities.

Suggestive Digital Platforms / Web Links

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx
4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

This course can be opted as Optional by the students of following subjects

Passed M. Sc.-II, Sem-IV

P.G. PHYSICS

Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test/Quiz/Assignment /Seminar 05 marks for Class Interaction
Course Prerequisites
Passed M. Sc.-II, Sem-III
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
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Programme/Class: **M. Sc.**	Year: **Second**	Semester: **X**
Subject: **Physics**		
Course Code: **B011006T**	Course Title: **Astronomy & Astrophysics**	

Course Objectives and Outcomes

Course Objectives:

The objective of this course is to make the students aware of the planets, their sizes, shapes, atmosphere and their satellites, How stars evolve and what is the source of stellar energy etc is.

Course Outcomes:

After completing this courses the students will be able to get the answers of:

1. how astronomical distances are measured?
2. what are composition, atmosphere, etc. of planets?
3. how many satellites are their around different planets?
4. how do stars (including sun) emit energy?
5. birth and death of stars.

Credits: **4**	Course: **Optional**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Measurement Techniques:** Methods of measurement of astronomical distances, measurement of mass, temperature, radius and velocity.	08
II	**Planets and their satellites:** The earth; shape, dimension and its interior. Atmosphere of earth, magnetic field and gravity, rotation and revolution; earth's precession, earth's distance from sun, perihelion and aphelion, Mercury as morning and evening star, Venus and its atmosphere. The red planet rotation & Mass, surface features, Hazy atmosphere, Climate and satellites of Mass, Asteroids and their orbits, Jupiter; Saturn and its rings, Constitution of Saturn, Discrete nature of rings, Origin of Saturn's rings.	18
III	**Classification of stars:** Classification of stellar spectra, Luminosity of stars, Mass – luminosity relation, stars of Main Sequence, Giant and dwarf stars, white dwarf stars.	10

IV	**Evolution of stars:** Protostar Jeans mass, hydrostatic equilibrium, equations of stellar structure, scaling relations sources of stellar energy, Gravitational collapse, Nuclear fusion reactions, proton – proton and carbon cycle, formation of heavy elements; r and s processes, evolution of low mass and high mass stars, white and brown dwarfs, Chandrashekhar limit, pulsars and neutron star.	**12**
V	**Galaxies:** Types and structural features , The Milky way Galaxy, stellar population in the galaxy, position of Sun, effect of rotation, interaction between galaxies. Active galatic nuclei and quasars.	**12**

Suggested Readings

1. Theoretical Astrophysics – T. Padmanabhan, Vol 1 – 3.
2. Astronomy – Robert H. Baker, D. Van Nostrand Company, INC.
3. Introduction to stellar evolution and nuclosynthesis.
4. The early universe – E. W. Kolb and M. S. Turner.

Course Books published in Hindi may be prescribed by the Universities.

P.G. PHYSICS

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as Optional by the students of following subjects
Passed M. Sc.-II, Sem-IV
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test/Quiz/Assignment /Seminar 05 marks for Class Interaction
Course Prerequisites
Passed M. Sc.-II, Sem-III
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
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P.G. PHYSICS

Programme/Class: **M. Sc.**	Year: **Second**	Semester: **X**
Subject: **Physics**		
Course Code: **B011007T**	Course Title: **General Theory of Relativity and Cosmology**	

Course Objectives and Outcomes

Course Objective: To develop a basic understanding of General Theory of Relativity and Cosmology.

Course Outcomes: The students will be able to develop a broader, advanced and more general understanding of the theory of Gravity and origin of universe.

Credits: **4**	Course: **Optional**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Review of Tensors:** Tensors in index notation, Kronecker and Levi Civita tensors, inner and outer products, contraction, symmetric and anti-symmetric tensors, metric tensors, covariant and contra-variant tensors, the Levi-Civita tensor, vector-fields, tensor fields, gradient and Laplace operator in general coordinates, parallel displacement and covariant differentiation, affine connection and its relation to metric tensor, curvature tensor and its symmetries, Bianchi identities.	18
II	**Origin of General Theory of Relativity:** Non-inertial frames and non-Euclidean geometry, general coordinate transformations and general covariance of Physical laws, Equality of gravitational and inertial masses, principle of equivalence, gravitational red and blue shift, experimental verification, Mach's principle.	12
III	**Gravity as Curved Geometry, Geodesics and Field Equations:** The space-time interval, the metric, Lorentz transformations, space-time diagrams, world lines, proper time, energy-momentum vector, energy-momentum tensor and conservation laws, geodesics and particle trajectories, equation of motion of particles, weak fields and Newtonian approximation, time and distance in general theory, gravitation as space-time curvature, Einstein field equation, Schwarzschild solution, radial motion towards centre, singularities, black holes, event horizon, general orbits, constants of motion, deflection of light, precession of perihelion and radar echo, standard, isotropic and harmonic coordinates.	16

IV	**Cosmology:** The cosmological principle, expansion of the universe, thermal history, standard cosmological model, Friedmann-Robertson-Walker models of the universe, primordial inflation and the theory of cosmological fluctuations, theory and observations of the cosmic microwave background and of the large-scale structure of the universe, dark matter and dark energy. Energy momentum tensor for a perfect fluid, action principle for field equations, Newtonian dust, conservation laws in curved space and pseudo energy tensor for gravitational field.	**14**

Suggested Readings

1. S. Carroll, Space-time and Geometry: An Introduction to General Relativity, (Addison Wesley, 2004)
2. J. Plebanski, A. Krasinski, An Introduction to General Relativity and Cosmology (Cambridge University Press, 2006).
3. C. W. Meisner, K. S. Thorne, J. Wheeler, Gravitation (W. H. Freeman & Co., San Francisco 1973).
4. R. M. Wald, Space, Time, and Gravity: the Theory of the Big Bang and Black Holes (University of Chicago Press 1992).
5. B. Schutz, A First Course in General Relativity (Cambridge University Press, 2009).
6. M. Carmeli, Cosmological Special Relativity-The Large Scale Structure of Space, Time and Velocity (World Scientific, 2002).
7. S. Weinberg, Cosmology (Oxford University Press, 2008).

Course Books published in Hindi may be prescribed by the Universities.

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as Optional by the students of following subjects
Passed Semester-III in Physics
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test/Quiz/Assignment /Seminar 05 marks for Class Interaction
Course Prerequisites
Passed Semester-III in Physics
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
• Other digital platforms /web links and Equivalent online courses may be suggested /added to the respective lists by individual Universities. • **In End-semester University Examination, equal weightage should be given to each unit 1-V while framing the questions.**

Programme/Class: **M. Sc.**	Year: **Second**	Semester: **X**
Subject: **Physics**		
Course Code: **B011008T**	Course Title: **Environmental Physics**	

Course Objectives and Outcomes

Course Objective: The primary goal to design this course is to develop concepts, understanding and describe various aspects of physics related to environmental processes and natural phenomena occurring in our everyday life. In addition, the course deals with state-of-the-art experimental and modelling approaches widely used in the environmental research field.

Course Outcomes: The students shall:

1. Learn, understand and gained enough knowledge within selected environmental physics topics such as (importance of studying environmental physics, Basic composition and dynamics of the atmosphere, How to apply basic thermodynamic law's to the environment, black body and Solar radiation, etc.).
2. Explain the problems of environmental pollution, Ozone depletion, Global warming, Green house effect and can explain the energy demand and role of renewable energy.
3. Express the operation and working principal of standard and modern experimental techniques for instance (LIDARS and RADARS) to estimate pressure, temperature wind etc.

Credits: **4**	Course: **Optional**
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
I	**Environmental Studies & Physical Meteorology:** Introduction to the course and importance of Environment, Atmospheric composition, Laws of thermodynamics of the atmosphere, Adiabatic processes, Potential temperature, The Clausius-Clapeyron equation, Radiative transfer and the laws of black body radiation, Solar and terrestrial radiation, Environmental applications in meteorology, Hydrology and Geophysics etc.	10
II	**Environmental Pollution & Renewable Sources of Energy:** Pollution: Air, Water, Soil, Marine, Noise, Thermal, Nuclear & Related Aspects, Technologies employed for industrial air emissions control, Characterizing the Air Stream, Equipment Selection, Different Types of Air Pollution, Control Techniques, Energy sources and combustion processes, environmental friendly source of energy.	14

III	**Necessity of Environmental Physics** Basics of the Atmospheric structure and thermodynamics, Composition of air, Greenhouse effect, Transport of matter, Energy and momentum in nature, The fundamental forces, Hydrostatic equation, The circulation theorem, Weather and climatic factors in India.	**12**
IV	**Solar and Terrestrial Radiation** Physics of ionizing radiation and radioactivity, Interaction of light with matter, Rayleigh and Mie scattering, Laws of radiation, Solar and terrestrial spectra, UV-radiation and the Ozone layer, IR absorption, Energy balance of the earth atmospheric system, Earthquakes, Seismic waves.	**14**
V	**Experimental Techniques in Environmental Physics, Global and Local Climate** Conventional measurement of pressure, Temperature, Humidity, Wind, Precipitation, Visibility, Modern Observational Techniques: (LIDARS, RADARS. etc.,). Climate change and Global warming, Weather conditions and climate modelling	**10**

Suggested Readings

1. Gerard Kiely, Environmental Engineering, McGraw Hill Education, Special Indian Edition, 2007.
2. Gilbert M. Masters and Wendell P. Ella, Introduction to Environmental Engineering and Sciences, PHI Learning Private Ltd, 3 rd Edition, 2007.
3. Bocker, E & Groundelle, R. V. : Environmental Physics, (John Wiley)
4. Salby, M.L. : Fundamentals of Atmospheric Physics (Academic Press)
5. Keshavamurty, R. N. & S. Rao, M . : The Physics of Monsoons (Allied Publishers)
6. Iribarne, J.V. and Godson, W.L. : Atmospheric Thermodynamics (D. Reidel)
7. Houghton, J. T. : The Physics of Atmosphere (Cambridge)
8. Vallace, J.M. and Hobbs, P.W. : Atmospheric Science: An Introductory Survey (Academic Press)
9. Mason, N. and Hughes, P.: Introduction to Environmental Physics: Planet Earth, Life and Climate, Taylor and Francis, 2001.

Course Books published in Hindi may be prescribed by the Universities.

P.G. PHYSICS

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as Optional by the students of following subjects
M Sc.II Sem-IV
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test/Quiz/Assignment /Seminar 05 marks for Class Interaction
Course Prerequisites
Passed Sem-III in Physics
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
Further Suggestions
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P.G. PHYSICS

Programme/Class: **M. Sc.**	Year: **Second**	Semester: **X**
Subject: **Physics**		
Course Code: **B011009P**	Course Title: **Special Lab**	

Course Objective & Outcomes

Course Objective: The experiments are an essential and inseparable part of Physics Course. The validity of various Laws and observations are tested through experiments in the Lab.

Course Outcomes: The results of an experiment (in agreement/deviated from the established pattern) enable the students to recognise the faults/errors in his approach and encourages to repeat the experiment with an improved approach.

Credits:**01**	Course: **Core (Compulsory)**
Max. Marks: **25+75** One Practical: 40 Marks Record: 10 Marks Viva-Voce: 20 Marks Attendance: 05 Marks.	Min. Passing Marks:

Total No. of Lectures-Tutorials-**Practical (in hours per week)**: L-T-P: 0-0-**2**

Unit	Topics	No. of Hours
	1. D/A Converter 2. A/D Converter 3. Multiplexer 4. De Multiplexer 5. Active Filter 6. Transistor feed back Amplifier 7. Microprocessor 8085 8. A.L.U 9. Pulse Amplitude Modulation. 10. Study of OP – amp741 as summer, differentiator and integrator. 11. Astronomical Telescope 12. Four probe 13. Study of Combinational Circuits	**30**

Note:

- The student has to do a minimum of six experiments from the given list.
- In the practical examination the student will be asked to perform one experiment of two hours duration.

Suggested Readings

1. Electronic Principles – A. Malvino, D.J. Bates 7th ed TMH, N. Delhi.
2. Microelectronic Circuit and Devices – Mark N. Horenstein, Pearson 2nd ed.
3. Fundamentals of Analog Circuits – Floyd, Buchla 2nd ed, Pearson – 2017.
4. Digital System – R.J. Tocci, PHI 6th ed, 2000.
5. Digital Logic and Computer Design – M. Morris Mano, PHI, Delhi 1996.
6. Integrated Electronics: Analog and Digital circuits and Systems, J. Millman, C. C. Halkias, TMH, Edition 1991.

Course Books published in Hindi may be prescribed by the Universities.

P.G. PHYSICS

Suggestive Digital Platforms / Web Links
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
This course can be opted as a Major (Core) by the students of following subjects
M.Sc.-II, Sem-III
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar/ 05 marks for Class Interaction
Course Prerequisites
Passed M. Sc.-I, Sem-II
Suggested Equivalent Online Courses
1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 2. edX, https://www.edx.org/course/subject/physics 3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/ 4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 5. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
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P.G. PHYSICS