DR. BHIM RAO AMBEDKAR UNIVERSITY, AGRA

NATIONAL EDUCATION POLICY-2020

STRUCTURE AND SYLLABUS OF PHYSICS

For

Under Graduate (UG) Programme

Four Year Undergraduate Programme (FYUP)

Post Graduate (PG) Programme

(Effective From Academic Session 2025-26)

DR. BHIM RAO AMBEDKAR UNIVERSITY, AGRA

BOARD OF STUDIES – PHYSICS
MINUTES OF MEETING

Meeting of Board of Studies of Physics was held on 11-July-2025, at the Department of Physics, Agra College, Agra, on the agenda: "Alignment of Physics Syllabus for Five Years of Higher Education with Four Year Undergraduate Programme (FYUP)". Following members attended the meeting –

S. No.	NAME	DESIGNATION	AFFILIATION
	MEMBERS OF BOARD OF STUDIES		
	Prof. Ajay Kumar	**Professor & Convener of BOS**	**Department of Physics, R.B.S. College, Agra**
1.	Prof. Brijendra Kumar Sharma	Professor	Department of Physics, Agra College, Agra
2.	Prof. Amar Kumar	Professor	Department of Physics, K.R.P.G. College, Mathura
3.	Prof. Neera Sharma	Professor	Department of Physics, Agra College, Agra
4.	Prof. Randhir Singh Indoliya	Professor	Department of Physics, Agra College, Agra
5.	Prof. Vikram Singh	Professor	Department of Physics, Agra College, Agra
6.	Prof. Anil Kumar Das	Professor	Department of Physics, St. John's College, Agra
	SPECIAL INVITEES		
1.	Prof. Gaurang Misra	Professor	Department of Physics, Agra College, Agra

All the above members recommended the following:

1. In the First Three Years of Higher Education, the currently running Common Minimum Physics Syllabus for all U.P. State Universities and Colleges will remain applicable.
2. Indian Knowledge System (IKS), introduced in the first unit of theory paper (B010101T) of Semester I of First Year of Higher Education, has been amplified.
3. Research Project of Credit 3, in Semester V & VI of Third Year of Higher Education has been removed.
4. Research Project of Credit 3, in Semester IV of Second Year of Higher Education has been introduced.
5. In the Fourth & Fifth Year of Higher Education, the currently running M.Sc. Physics Syllabus will remain applicable with certain modifications in its Structure and Syllabus so as to align it with FYUP.
6. There will be no Continuous Internal Evaluation (CIE) in Practical Papers and Research Projects / Dissertations under FYUP.
7. **Structure and Syllabus of Physics under FYUP is annexed as below:**
   First Three Years - Page 3 to 51 Fourth Year - Page 52 to 68 Fifth Year - Page 69 to 92
8. **All the above amendments will be applicable only to the students admitted in the Academic Session 2025-26 in Semester I of First Year of Higher Education. All other students will complete their courses as per the previous rules.**
9. Papers related to the Syllabus of Physics, that can be opted through Swayam Portal were also discussed.

Signature of Members

Prof. Ajay Kumar
Convener of BOS

FIRST THREE YEARS OF HIGHER EDUCATION

DEPARTMENT OF HIGHER EDUCATION U.P. GOVERNMENT, LUCKNOW

National Education Policy-2020

Common Minimum Syllabus For All U.P. State Universities And Colleges

For First Three Years of Higher Education

S. No.	NAME	DESIGNATION	AFFILIATION
		STEERING COMMITTEE	
	Mrs. Monika S. Garg ***(I.A.S.)***	**ACS & Chairperson**	**Department of Higher Education U.P. Government, Lucknow**
1.	Prof. Poonam Tandan *(Ph.D.)*	Professor	Department of Physics University of Lucknow, Lucknow, U.P.
2.	Prof. Hare Krishna *(Ph.D.)*	Professor	Department of Statistics C.C.S. University, Meerut, U.P.
3.	Prof. Dinesh C. Sharma *(Ph.D.)*	Professor	Department of Zoology K.M. Govt. Girls P.G. College Badalpur, G.B. Nagar, U.P.
		SUPERVISORY COMMITTEE - SCIENCE FACULTY	
	Prof. Vijay Kumar Singh ***(Ph.D.)***	**Professor & Convener**	**Department of Zoology Agra College, Agra, U.P.**
1.	Prof. Santosh Singh *(Ph.D.)*	Professor & Dean	Department of Agriculture Mahatma Gandhi Kashi Vidhyapeeth, Varanasi, U.P.
2.	Prof. Baby Tabussam *(Ph.D.)*	Professor	Department of Zoology Govt. Raza P.G. College Rampur, U.P.
3.	Prof. Sanjay Jain *(Ph.D.)*	Professor	Department of Statistics St. John's College, Agra, U.P.
		SYLLABUS DEVELOPED BY – SUBJECT PHYSICS	
	Prof. Gaurang Misra ***(Ph.D.)***	**Professor & Convener**	**Department of Physics Agra College, Agra, U.P.**
1.	Dr. Naresh K. Chaudhary *(Ph.D.)*	Associate Professor	Department of Physics & Electronics Dr. R.M.L.A. University, Faizabad, U.P.
2.	Dr. Vikram Singh *(Ph.D.)*	Assistant Professor	Department of Physics St. John's College, Agra, U.P.

STRUCTURE OF PHYSICS COURSE IN FIRST THREE YEARS OF HIGHER EDUCATION						
YEAR	**SEMESTER**	**COURSE CODE**	**PAPER TITLE**	**PAPER NATURE**	**CREDIT**	**PAGE No.**
CERTIFICATE (BASIC PHYSICS & SEMICONDUCTOR DEVICES)						**08 - 19**
FIRST YEAR	I	B010101T	Mathematical Physics & Newtonian Mechanics	Theory	4	10 - 12
		B010102P	Mechanical Properties of Matter	Practical	2	13 - 14
	II	B010201T	Thermal Physics & Semiconductor Devices	Theory	4	15 - 17
		B010202P	Thermal Properties of Matter & Electronic Circuits	Practical	2	18 - 19
DIPLOMA (APPLIED PHYSICS WITH ELECTRONICS)						**20 - 32**
SECOND YEAR	III	B010301T	Electromagnetic Theory & Modern Optics	Theory	4	22 - 24
		B010302P	Demonstrative Aspects of Electricity & Magnetism	Practical	2	25 - 26
	IV	B010401T	Perspectives of Modern Physics & Basic Electronics	Theory	4	27 - 29
		B010402P	Basic Electronics Instrumentation	Practical	2	30 - 31
		B010403R	Research Project in Physics	Research	3	32
DEGREE IN BACHELOR OF SCIENCE						**33 - 51**
THIRD YEAR	V	B010501T	Classical & Statistical Mechanics	Theory	4	35 - 37
		B010502T	Quantum Mechanics & Spectroscopy	Theory	4	38 - 40
		B010503P	Demonstrative Aspects of Optics & Lasers	Practical	2	41 - 42
	VI	B010601T	Solid State & Nuclear Physics	Theory	4	43 - 45
		B010602T	Analog & Digital Principles & Applications	Theory	4	46 - 48
		B010603P	Analog & Digital Circuits	Practical	2	49 - 51

SUBJECT PREREQUISITES

To study this subject, a student must have had the subjects **Physics & Mathematics** in class 12th.

PROGRAMME OUTCOMES (POs)

The practical value of science for productivity, for raising the standard of living of the people is surely recognized. Science as a power, which provides tools for effective action for the benefit of mankind or for conquering the forces of Nature or for developing resources, is surely highlighted everywhere. Besides the utilitarian aspect, the value of Science, lies in the fun called intellectual enjoyment. Science teaches the value of rational thought as well as importance of freedom of thought.

Our teaching so far has been aimed more at formal knowledge and understanding instead of training and application oriented. Presently, the emphasis is more on training, application and to some extent on appreciation, the fostering in the pupils of independent thinking and creativity. Surely, teaching has to be more objective based. The process of application based training, whether we call it a thrill or ability, is to be emphasized as much as the content.

Physics is a basic science; it attempts to explain the natural phenomenon in as simple a manner as possible. It is an intellectual activity aimed at interpreting the Multiverse. The starting point of all physics lies in experience. Experiment, whether done outside or in the laboratory, is an important ingredient of learning physics and hence the present programme integrates six experimental physics papers focusing on various aspects of modern technology based equipments. With all the limitations imposed (even the list of experiments as given in the syllabus) if the spirit of discovery by investigation is kept in mind, much of the thrill can be experienced.

1. The main aim of this programme is to help cultivate the love for Nature and its manifestations, to transmit the methods of science (the contents are only the means) to observe things around, to generalize, to do intelligent guessing, to formulate a theory & model, and at the same time, to hold an element of doubt and thereby to hope to modify it in terms of future experience and thus to practice a pragmatic outlook.
2. The programme intends to nurture the proficiency in functional areas of Physics, which is in line with the international standards, aimed at realizing the goals towards skilled India.
3. Keeping the application oriented training in mind; this programme aims to give students the competence in the methods and techniques of theoretical, experimental and computational aspects of Physics so as to achieve an overall understanding of the subject for holistic development. This will cultivate in specific application oriented training leading to their goals of employment.
4. The Bachelor's Project (Industrial Training / Survey / Dissertation) is intended to give an essence of research work for excellence in explicit areas. It integrates with specific job requirements / opportunities and provides a foundation for Bachelor (Research) Programmes.

PROGRAMME SPECIFIC OUTCOMES (PSOs)	
CERTIFICATE (BASIC PHYSICS & SEMICONDUCTOR DEVICES)	
FIRST YEAR	This programme aims to give students the competence in the methods and techniques of calculations using Newtonian Mechanics and Thermodynamics. At the end of the course the students are expected to have hands on experience in modeling, implementation and calculation of physical quantities of relevance. An introduction to the field of Circuit Fundamentals and Basic Electronics which deals with the physics and technology of semiconductor devices is practically useful and gives the students an insight in handling electrical and electronic instruments. Experimental physics has the most striking impact on the industry wherever the instruments are used. The industries of electronics, telecommunication and instrumentation will specially recognize this course.
DIPLOMA (APPLIED PHYSICS WITH ELECTRONICS)	
SECOND YEAR	This programme aims to introduce the students with Electromagnetic Theory, Modern Optics and Relativistic Mechanics. Electromagnetic Wave Propagation serves as a basis for all communication systems and deals with the physics and technology of semiconductor optoelectronic devices. A deeper insight in Electronics is provided to address the important components in consumer Optoelectronics, IT and Communication devices, and in industrial instrumentation. The need of Optical instruments and Lasers is surely highlighted everywhere and at the end of the course the students are expected to get acquaint with applications of Lasers in technology. Companies and R&D Laboratories working on Electromagnetic properties, Laser Applications, Optoelectronics and Communication Systems are expected to value this course.
DEGREE IN BACHELOR OF SCIENCE	
THIRD YEAR	This programme contains very important aspects of modern day course curriculum, namely, Classical, Quantum and Statistical computational tools required in the calculation of physical quantities of relevance in interacting many body problems in physics. It introduces the branches of Solid State Physics and Nuclear Physics that are going to be of utmost importance at both undergraduate and graduate level. Proficiency in this area will attract demand in research and industrial establishments engaged in activities involving applications of these fields. This course amalgamates the comprehensive knowledge of Analog & Digital Principles and Applications. It presents an integrated approach to analog electronic circuitry and digital electronics. Present course will attract immense recognition in R&D sectors and in the entire cutting edge technology based industry.

DETAILED PHYSICS SYLLABUS FOR FIRST YEAR OF HIGHER EDUCATION

YEAR	SEME-STER	PAPER	PAPER TITLE	UNIT TITLE (Periods Per Semester)
CERTIFICATE IN BASIC PHYSICS & SEMICONDUCTOR DEVICES				
FIRST YEAR	SEMESTER I	Theory Paper-1	**Mathematical Physics & Newtonian Mechanics** Part A: Basic Mathematical Physics Part B: Newtonian Mechanics & Wave Motion	**Part A** I: IKS & Vector Algebra (8) II: Vector Calculus (7) III: Coordinate Systems (8) IV: Introduction to Tensors (7) **Part B** V: Dynamics of a System of Particles (8) VI: Dynamics of a Rigid Body (8) VII: Motion of Planets & Satellites (7) VIII: Wave Motion (7)
		Practical Paper	**Mechanical Properties of Matter**	Lab Experiment List Online Virtual Lab Experiment List/Link
	SEMESTER II	Theory Paper-1	**Thermal Physics & Semiconductor Devices** Part A: Thermodynamics & Kinetic Theory of Gases Part B: Circuit Fundamentals & Semiconductor Devices	**Part A** I: 0^{th} & 1^{st} Law of Thermodynamics (8) II: 2^{nd} & 3^{rd} Law of Thermodynamics (8) III: Kinetic Theory of Gases (7) IV: Theory of Radiation (7) **Part B** V: DC & AC Circuits (7) VI: Semiconductors & Diodes (8) VII: Transistors (8) VIII: Electronic Instrumentation (7)
		Practical Paper	**Thermal Properties of Matter & Electronic Circuits**	Lab Experiment List Online Virtual Lab Experiment List/Link

Programme/Class: **Certificate**	Year: **First (1st)**	Semester: **First (I)**
Subject: **Physics**		
Course Code: **B010101T**	Course Title: **Mathematical Physics & Newtonian Mechanics**	

Course Outcomes (COs)

1. Recognize the difference between scalars, vectors, pseudo-scalars and pseudo-vectors.
2. Understand the physical interpretation of gradient, divergence and curl.
3. Comprehend the difference and connection between Cartesian, spherical and cylindrical coordinate systems.
4. Know the meaning of 4-vectors, Kronecker delta and Epsilon (Levi Civita) tensors.
5. Understand the origin of pseudo forces in rotating frame.
6. Understand the response of the classical systems to external forces and their elastic deformation.
7. Understand the dynamics of planetary motion and the working of Global Positioning System (GPS).
8. Comprehend the different features of Simple Harmonic Motion (SHM) and wave propagation.

Credits: **4**	Core Compulsory (Major) / Elective (Minor)
Max. Marks: **25 (CIE) + 75 (University Exam)**	Min. Passing Marks: As per University Norms

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

Unit	Topics	No. of Lectures
	PART A **Basic Mathematical Physics**	
I	**Indian Knowledge System (IKS)** History and evolution of Physical Sciences in India under the framework of Indian Knowledge System (IKS). Introduction to Indian ancient Physics and contribution of Indian Scholars in Physics in context with the holistic development of modern science and technology. **Vector Algebra** Coordinate rotation, reflection and inversion as the basis for defining scalars, vectors, pseudo-scalars and pseudo-vectors (include physical examples). Component form in 2D and 3D. Geometrical and physical interpretation of addition, subtraction, dot product, wedge product, cross product and triple product of vectors. Position, separation and displacement vectors.	8
II	**Vector Calculus** Geometrical and physical interpretation of vector differentiation, Gradient, Divergence and Curl and their significance. Vector integration, Line, Surface (flux) and Volume integrals of vector fields. Gradient theorem, Gauss-divergence theorem, Stoke-curl theorem, Greens theorem and Helmholtz theorem (statement only). Introduction to Dirac delta function.	7
III	**Coordinate Systems** 2D & 3D Cartesian, Spherical and Cylindrical coordinate systems, basis vectors, transformation equations. Expressions for displacement vector, arc length, area element, volume element, gradient, divergence and curl in different coordinate systems. Components of velocity and acceleration in different coordinate systems. Examples of non-inertial coordinate system and pseudo-acceleration.	8

IV	**Introduction to Tensors** Principle of invariance of physical laws w.r.t. different coordinate systems as the basis for defining tensors. Coordinate transformations for general spaces of nD, contravariant, covariant & mixed tensors and their ranks, 4-vectors. Index notation and summation convention. Symmetric and skew-symmetric tensors. Invariant tensors, Kronecker delta and Epsilon (Levi Civita) tensors. Examples of tensors in physics.	7
	PART B **Newtonian Mechanics & Wave Motion**	
V	**Dynamics of a System of Particles** Review of historical development of mechanics up to Newton. Background, statement and critical analysis of Newton's axioms of motion. Dynamics of a system of particles, centre of mass motion, and conservation laws & their deductions. Rotating frames of reference, general derivation of origin of pseudo forces (Euler, Coriolis & centrifugal) in rotating frame, and effects of Coriolis force.	8
VI	**Dynamics of a Rigid Body** Angular momentum, Torque, Rotational energy and the inertia tensor. Rotational inertia for simple bodies (ring, disk, rod, solid and hollow sphere, solid and hollow cylinder, rectangular lamina). The combined translational and rotational motion of a rigid body on horizontal and inclined planes. Elasticity, relations between elastic constants, bending of beam and torsion of cylinder.	8
VII	**Motion of Planets & Satellites** Two particle central force problem, reduced mass, relative and centre of mass motion. Newton's law of gravitation, gravitational field and gravitational potential. Kepler's laws of planetary motion and their deductions. Motions of geo-synchronous & geo-stationary satellites and basic idea of Global Positioning System (GPS).	7
VIII	**Wave Motion** Differential equation of simple harmonic motion and its solution, use of complex notation, damped and forced oscillations, Quality factor. Composition of simple harmonic motion, Lissajous figures. Differential equation of wave motion. Plane progressive waves in fluid media, reflection of waves and phase change, pressure and energy distribution. Principle of superposition of waves, stationary waves, phase and group velocity.	7

Suggested Readings

PART A

1. Murray Spiegel, Seymour Lipschutz, Dennis Spellman, "Schaum's Outline Series: Vector Analysis", McGraw Hill, 2017, 2e
2. A.W. Joshi, "Matrices and Tensors in Physics", New Age International Private Limited, 1995, 3e

PART B

1. Charles Kittel, Walter D. Knight, Malvin A. Ruderman, Carl A. Helmholz, Burton J. Moyer, "Mechanics (In SI Units): Berkeley Physics Course Vol 1", McGraw Hill, 2017, 2e
2. Richard P. Feynman, Robert B. Leighton, Matthew Sands, "The Feynman Lectures on Physics - Vol. 1", Pearson Education Limited, 2012
3. Hugh D. Young and Roger A. Freedman, "Sears & Zemansky's University Physics with Modern Physics", Pearson Education Limited, 2017, 14e
4. D.S. Mathur, P.S. Hemne, "Mechanics", S. Chand Publishing, 1981, 3e

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual 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
Course Prerequisites
As per University Guidelines
This course can be opted as an Elective by the students of following subjects
Faculty of Science
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar 05 marks for Class Interaction
Suggested Equivalent Online Courses
1. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html 3. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 4. edX, https://www.edx.org/course/subject/physics 5. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/
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 Examinations, equal weightage should be given to Part A (units I to IV) and Part B (units V to VIII) while framing the questions.**

Programme/Class: **Certificate**	Year: **First (1st)**	Semester: **First (I)**
Subject: **Physics**		
Course Code: **B010102P**	Course Title: **Mechanical Properties of Matter**	

Course Outcomes (COs)

Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the mechanical properties. Measurement precision and perfection is achieved through Lab Experiments. Online Virtual Lab Experiments give an insight in simulation techniques and provide a basis for modeling.

Credits: **2**	Core Compulsory (Major)
Max. Marks: **100 (University Exam)**	Min. Passing Marks: As per University Norms

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

Unit	**Topics**	**No. of Lectures**
	Lab Experiment List 1. Moment of inertia of a flywheel 2. Moment of inertia of an irregular body by inertia table 3. Modulus of rigidity by statistical method (Barton's apparatus) 4. Modulus of rigidity by dynamical method (sphere / disc / Maxwell's needle) 5. Young's modulus by bending of beam 6. Young's modulus and Poisson's ratio by Searle's method 7. Poisson's ratio of rubber by rubber tubing 8. Surface tension of water by capillary rise method 9. Surface tension of water by Jaeger's method 10. Coefficient of viscosity of water by Poiseuille's method 11. Acceleration due to gravity by bar pendulum 12. Frequency of AC mains by Sonometer 13. Height of a building by Sextant 14. Study the wave form of an electrically maintained tuning fork / alternating current source with the help of cathode ray oscilloscope. **Online Virtual Lab Experiment List / Link** Virtual Labs at Amrita Vishwa Vidyapeetham https://vlab.amrita.edu/?sub=1&brch=74 1. Torque and angular acceleration of a fly wheel 2. Torsional oscillations in different liquids 3. Moment of inertia of flywheel 4. Newton's second law of motion 5. Ballistic pendulum 6. Collision balls 7. Projectile motion 8. Elastic and inelastic collision	60

Suggested Readings
1. B.L. Worsnop, H.T. Flint, "Advanced Practical Physics for Students", Methuen & Co., Ltd., London, 1962, 9e 2. S. Panigrahi, B. Mallick, "Engineering Practical Physics", Cengage Learning India Pvt. Ltd., 2015, 1e 3. Lab Experiment Manuals ***Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual Universities.***
Suggestive Digital Platforms / Web Links
1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74 2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities.
Course Prerequisites
As per University Guidelines
This course can be opted as an Elective by the students of following subjects
-NA-
Suggested Continuous Internal Evaluation (CIE) Methods
-NA-
Suggested Equivalent Online Courses
Further Suggestions
• The institution may add / modify / change the experiments of the same standard in the subject. • The institution may suggest a minimum number of experiments (say 6) to be performed by each student per semester from the Lab Experiment List. • The institution may suggest a minimum number of experiments (say 3) to be performed by each student per semester from the Online Virtual Lab Experiment List / Link.

Programme/Class: **Certificate**	Year: **First (1st)**	Semester: **Second (II)**
Subject: **Physics**		
Course Code: **B010201T**	Course Title: **Thermal Physics & Semiconductor Devices**	

Course Outcomes (COs)

1. Recognize the difference between reversible and irreversible processes.
2. Understand the physical significance of thermodynamical potentials.
3. Comprehend the kinetic model of gases w.r.t. various gas laws.
4. Understand the implementations and limitations of fundamental radiation laws.
5. Utility of AC bridges.
6. Recognize the basic components of electronic devices.
7. Design simple electronic circuits.
8. Understand the applications of various electronic instruments.

Credits: **4**	Core Compulsory (Major) / Elective (Minor)
Max. Marks: **25 (CIE) + 75 (University Exam)**	Min. Passing Marks: As per University Norms

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

Unit	Topics	No. of Lectures
	PART A **Thermodynamics & Kinetic Theory of Gases**	
I	**0th & 1st Law of Thermodynamics** State functions and terminology of thermodynamics. Zeroth law and temperature. First law, internal energy, heat and work done. Work done in various thermodynamical processes. Enthalpy, relation between C_P and C_V. Carnot's engine, efficiency and Carnot's theorem. Efficiency of internal combustion engines (Otto and diesel).	8
II	**2nd & 3rd Law of Thermodynamics** Different statements of second law, Clausius inequality, entropy and its physical significance. Entropy changes in various thermodynamical processes. Third law of thermodynamics and unattainability of absolute zero. Thermodynamical potentials, Maxwell's relations, conditions for feasibility of a process and equilibrium of a system. Clausius- Clapeyron equation, Joule-Thompson effect.	8
III	**Kinetic Theory of Gases** Kinetic model and deduction of gas laws. Derivation of Maxwell's law of distribution of velocities and its experimental verification. Degrees of freedom, law of equipartition of energy (no derivation) and its application to specific heat of gases (mono, di and poly atomic).	7
IV	**Theory of Radiation** Blackbody radiation, spectral distribution, concept of energy density and pressure of radiation. Derivation of Planck's law, deduction of Wien's distribution law, Rayleigh-Jeans law, Stefan-Boltzmann law and Wien's displacement law from Planck's law.	7

PART B Circuit Fundamentals & Semiconductor Devices		
V	**DC & AC Circuits** Growth and decay of currents in RL circuit. Charging and discharging of capacitor in RC, LC and RCL circuits. Network Analysis - Superposition, Reciprocity, Thevenin's and Norton's theorems. AC Bridges - measurement of inductance (Maxwell's, Owen's and Anderson's bridges) and measurement of capacitance (Schering's, Wein's and de Sauty's bridges).	7
VI	**Semiconductors & Diodes** P and N type semiconductors, qualitative idea of Fermi level. Formation of depletion layer in PN junction diode, field & potential at the depletion layer. Qualitative idea of current flow mechanism in forward & reverse biased diode. Diode fabrication. PN junction diode and its characteristics, static and dynamic resistance. Principle, structure, characteristics and applications of Zener, Tunnel, Light Emitting, Point Contact and Photo diodes. Half and Full wave rectifiers, calculation of ripple factor, rectification efficiency and voltage regulation. Basic idea about filter circuits and voltage regulated power supply.	8
VII	**Transistors** Bipolar Junction PNP and NPN transistors. Study of CB, CE & CC configurations w.r.t. active, cutoff & saturation regions; characteristics; current, voltage & power gains; transistor currents & relations between them. Idea of base width modulation, base spreading resistance & transition time. DC Load Line analysis and Q-point stabilisation. Qualitative discussion of transistor as an amplifier and AC Load Line analysis.	8
VIII	**Electronic Instrumentation** Multimeter: Principles of measurement of dc voltage, dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. Cathode Ray Oscilloscope: Block diagram of basic CRO. Construction of CRT, electron gun, electrostatic focusing and acceleration (no mathematical treatment). Front panel controls, special features of dual trace CRO, specifications of a CRO and their significance. Applications of CRO to study the waveform and measurement of voltage, current, frequency & phase difference.	7

Suggested Readings

PART A

1. M.W. Zemansky, R. Dittman, "Heat and Thermodynamics", McGraw Hill, 1997, 7e
2. F.W. Sears, G.L. Salinger, "Thermodynamics, Kinetic theory & Statistical thermodynamics", Narosa Publishing House, 1998
3. Enrico Fermi, "Thermodynamics", Dover Publications, 1956
4. S. Garg, R. Bansal, C. Ghosh, "Thermal Physics", McGraw Hill, 2012, 2e
5. Meghnad Saha, B.N. Srivastava, "A Treatise on Heat", Indian Press, 1973, 5e

PART B

1. R.L. Boylestad, L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice-Hall of India Pvt. Ltd., 2015, 11e
2. J. Millman, C.C. Halkias, Satyabrata Jit, "Electronic Devices and Circuits", McGraw Hill, 2015, 4e
3. B.G. Streetman, S.K. Banerjee, "Solid State Electronic Devices", Pearson Education India, 2015, 7e
4. J.D. Ryder, "Electronic Fundamentals and Applications", Prentice-Hall of India Private Limited, 1975, 5e
5. A. Sudhakar, S.S. Palli, "Circuits and Networks: Analysis and Synthesis", McGraw Hill, 2015, 5e
6. S.L. Gupta, V. Kumar, "Hand Book of Electronics", Pragati Prakashan, Meerut, 2016, 43e

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual Universities.

V Singh

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
Course Prerequisites
As per University Guidelines
This course can be opted as an Elective by the students of following subjects
Faculty of Science
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar 05 marks for Class Interaction
Suggested Equivalent Online Courses
1. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html 3. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 4. edX, https://www.edx.org/course/subject/physics 5. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/
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 Examinations, equal weightage should be given to Part A (units I to IV) and Part B (units V to VIII) while framing the questions.**

<table>
<tr><td>Programme/Class: Certificate</td><td colspan="2">Year: First (1st)</td><td>Semester: Second (II)</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course Code: B010202P</td><td colspan="3">Course Title: Thermal Properties of Matter & Electronic Circuits</td></tr>
<tr><td colspan="4">Course Outcomes (COs)</td></tr>
<tr><td colspan="4">Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the thermal and electronic properties. Measurement precision and perfection is achieved through Lab Experiments. Online Virtual Lab Experiments give an insight in simulation techniques and provide a basis for modeling.</td></tr>
<tr><td colspan="2">Credits: 2</td><td colspan="2">Core Compulsory (Major)</td></tr>
<tr><td colspan="2">Max. Marks: 100 (University Exam)</td><td colspan="2">Min. Passing Marks: As per University Norms</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-4</td></tr>
<tr><td>Unit</td><td colspan="2">Topics</td><td>No. of Lectures</td></tr>
<tr><td></td><td colspan="2">Lab Experiment List
1. Mechanical Equivalent of Heat by Callender and Barne's method
2. Coefficient of thermal conductivity of copper by Searle's apparatus
3. Coefficient of thermal conductivity of rubber
4. Coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method
5. Value of Stefan's constant
6. Verification of Stefan's law
7. Variation of thermo-emf across two junctions of a thermocouple with temperature
8. Temperature coefficient of resistance by Platinum resistance thermometer
9. Charging and discharging in RC and RCL circuits
10. A.C. Bridges: Various experiments based on measurement of L and C
11. Resonance in series and parallel RCL circuit
12. Characteristics of PN Junction, Zener, Tunnel, Light Emitting and Photo diode
13. Characteristics of a transistor (PNP and NPN) in CE, CB and CC configurations
14. Half wave & full wave rectifiers and Filter circuits
15. Unregulated and Regulated power supply
16. Various measurements with Cathode Ray Oscilloscope (CRO)
Online Virtual Lab Experiment List / Link
Thermal Properties of Matter:
Virtual Labs at Amrita Vishwa Vidyapeetham
https://vlab.amrita.edu/?sub=1&brch=194
1. Heat transfer by radiation
2. Heat transfer by conduction
3. Heat transfer by natural convection
4. The study of phase change
5. Black body radiation: Determination of Stefan's constant
6. Newton's law of cooling
7. Lee's disc apparatus
8. Thermo-couple: Seebeck effects</td><td>60</td></tr>
</table>

	Semiconductor Devices: Virtual Labs an initiative of MHRD Govt. of India http://vlabs.iitkgp.ac.in/be/# 9. Familiarisation with resistor 10. Familiarisation with capacitor 11. Familiarisation with inductor 12. Ohm's Law 13. RC Differentiator and integrator 14. VI characteristics of a diode 15. Half & Full wave rectification 16. Capacitative rectification 17. Zener Diode voltage regulator 18. BJT common emitter characteristics 19. BJT common base characteristics 20. Studies on BJT CE amplifier	

Suggested Readings

1. B.L. Worsnop, H.T. Flint, "Advanced Practical Physics for Students", Methuen & Co., Ltd., London, 1962, 9e
2. S. Panigrahi, B. Mallick, "Engineering Practical Physics", Cengage Learning India Pvt. Ltd., 2015, 1e
3. Lab Experiment Manuals

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual Universities.

Suggestive Digital Platforms / Web Links

1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=194
2. Virtual Labs an initiative of MHRD Govt. of India, http://vlabs.iitkgp.ac.in/be/#
3. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities.

Course Prerequisites

As per University Guidelines

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

-NA-

Suggested Continuous Internal Evaluation (CIE) Methods

-NA-

Suggested Equivalent Online Courses

Further Suggestions

- The institution may add / modify / change the experiments of the same standard in the subject.
- The institution may suggest a minimum number of experiments (say 6) to be performed by each student per semester from the Lab Experiment List.
- The institution may suggest a minimum number of experiments (say 3) to be performed by each student per semester from the Online Virtual Lab Experiment List / Link.

DETAILED PHYSICS SYLLABUS
FOR
SECOND YEAR
OF HIGHER EDUCATION

YEAR	SEMESTER	PAPER	PAPER TITLE	UNIT TITLE (Periods Per Semester)
DIPLOMA IN APPLIED PHYSICS WITH ELECTRONICS				
SECOND YEAR	**SEMESTER III**	Theory Paper-1	**Electromagnetic Theory & Modern Optics** Part A: Electromagnetic Theory Part B: Physical Optics & Lasers	**Part A** I: Electrostatics (8) II: Magnetostatics (8) III: Time Varying Electromagnetic Fields (7) IV: Electromagnetic Waves (7) **Part B** V: Interference (8) VI: Diffraction (8) VII: Polarisation (7) VII: Lasers (7)
		Practical Paper	**Demonstrative Aspects of Electricity & Magnetism**	Lab Experiment List Online Virtual Lab Experiment List/Link
	SEMESTER IV	Theory Paper-1	**Perspectives of Modern Physics & Basic Electronics** Part A: Perspectives of Modern Physics Part B: Basic Electronics & Introduction to Fiber Optics	**Part A** I: Relativity-Experimental Background (7) II: Relativity-Relativistic Kinematics (8) III: Inadequacies of Classical Mechanics (8) IV: Introduction to Quantum Mechanics (7) **Part B** V: Transistor Biasing (7) VI: Amplifiers (7) VII: Feedback & Oscillator Circuits (8) VIII: Introduction to Fiber Optics (8)
		Practical Paper	**Basic Electronics Instrumentation**	Lab Experiment List Online Virtual Lab Experiment List/Link
		Research Project	**Research Project in Physics**	As per University Guidelines

Programme/Class: **Diploma**	Year: **Second (2^{nd})**	Semester: **Third (III)**
Subject: **Physics**		
Course Code: **B010301T**	Course Title: **Electromagnetic Theory & Modern Optics**	

Course Outcomes (COs)

1. Better understanding of electrical and magnetic phenomenon in daily life.
2. To troubleshoot simple problems related to electrical devices.
3. Comprehend the powerful applications of ballistic galvanometer.
4. Understand the fundamental physics behind reflection and refraction of light (electromagnetic waves).
5. Understand the working and applications of Michelson and Fabry-Perot interferometers.
6. Recognize the difference between Fresnel's and Fraunhofer's class of diffraction.
7. Comprehend the use of polarimeters.
8. Understand the characteristics and uses of lasers.

Credits: **4**	Core Compulsory (Major) / Elective (Minor)
Max. Marks: **25 (CIE) + 75 (University Exam)**	Min. Passing Marks: As per University Norms

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

Unit	Topics	No. of Lectures
	PART A **Electromagnetic Theory**	
I	**Electrostatics** Electric charge & charge densities, electric force between two charges. General expression for Electric field in terms of volume charge density (divergence & curl of Electric field), general expression for Electric potential in terms of volume charge density and Gauss law (applications included). Study of electric dipole. Electric fields in matter, polarization, auxiliary field **D** (Electric displacement), electric susceptibility and permittivity.	8
II	**Magnetostatics** Electric current & current densities, magnetic force between two current elements. General expression for Magnetic field in terms of volume current density (divergence and curl of Magnetic field), General expression for Magnetic potential in terms of volume current density and Ampere's circuital law (applications included). Study of magnetic dipole (Gilbert & Ampere model). Magnetic fields in matter, magnetisation, auxiliary field **H**, magnetic susceptibility and permeability.	8
III	**Time Varying Electromagnetic Fields** Faraday's laws of electromagnetic induction and Lenz's law. Displacement current, equation of continuity and Maxwell-Ampere's circuital law. Self and mutual induction (applications included). Derivation and physical significance of Maxwell's equations. Theory and working of moving coil ballistic galvanometer (applications included).	7
IV	**Electromagnetic Waves** Electromagnetic energy density and Poynting vector. Plane electromagnetic waves in linear infinite dielectrics, homogeneous & inhomogeneous plane waves and dispersive & non-dispersive media. Reflection and refraction of homogeneous plane electromagnetic waves, law of reflection, Snell's law, Fresnel's formulae (only for normal incidence & optical frequencies) and Stoke's law.	7

PART B Physical Optics & Lasers		
V	**Interference** Conditions for interference and spatial & temporal coherence. Division of Wavefront - Fresnel's Biprism and Lloyd's Mirror. Division of Amplitude - Parallel thin film, wedge shaped film and Newton's Ring experiment. Interferometer - Michelson and Fabry-Perot.	8
VI	**Diffraction** Distinction between interference and diffraction. Fresnel's and Fraunhofer's class of diffraction. Fresnel's Half Period Zones and Zone plate. Fraunhofer diffraction at a single slit, n slits and Diffracting Grating. Resolving Power of Optical Instruments - Rayleigh's criterion and resolving power of telescope, microscope & grating.	8
VII	**Polarisation** Polarisation by dichronic crystals, birefringence, Nicol prism, retardation plates and Babinet's compensator. Analysis of polarized light. Optical Rotation - Fresnel's explanation of optical rotation and Half Shade & Biquartz polarimeters.	7
VIII	**Lasers** Characteristics and uses of Lasers. Quantitative analysis of Spatial and Temporal coherence. Conditions for Laser action and Einstein's coefficients. Three and four level laser systems (qualitative discussion).	7

Suggested Readings

PART A

1. D.J. Griffiths, "Introduction to Electrodynamics", Prentice-Hall of India Private Limited, 2002, 3e
2. E.M. Purcell, "Electricity and Magnetism (In SI Units): Berkeley Physics Course Vol 2", McGraw Hill, 2017, 2e
3. Richard P. Feynman, Robert B. Leighton, Matthew Sands, "The Feynman Lectures on Physics - Vol. 2", Pearson Education Limited, 2012
4. D.C. Tayal, "Electricity and Magnetism", Himalaya Publishing House Pvt. Ltd., 2019, 4e

PART B

1. Francis A. Jenkins, Harvey E. White, "Fundamentals of Optics", McGraw Hill, 2017, 4e
2. Samuel Tolansky, "An Introduction to Interferometry", John Wiley & Sons Inc., 1973, 2e
3. A. Ghatak, "Optics", McGraw Hill, 2017, 6e

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual 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

Course Prerequisites

As per University Guidelines

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

Faculty of Science

Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar 05 marks for Class Interaction
Suggested Equivalent Online Courses
1. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html 3. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 4. edX, https://www.edx.org/course/subject/physics 5. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/
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 Examinations, equal weightage should be given to Part A (units I to IV) and Part B (units V to VIII) while framing the questions.**

Programme/Class: **Diploma**	Year: **Second (2nd)**	Semester: **Third (III)**
Subject: **Physics**		
Course Code: **B010302P**	Course Title: **Demonstrative Aspects of Electricity & Magnetism**	

Course Outcomes (COs)

Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the electric and magnetic properties. Measurement precision and perfection is achieved through Lab Experiments. Online Virtual Lab Experiments give an insight in simulation techniques and provide a basis for modeling.

Credits: **2**	Core Compulsory (Major)
Max. Marks: **100 (University Exam)**	Min. Passing Marks: As per University Norms

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

<table>
<tr><th>Unit</th><th>Topics</th><th>No. of Lectures</th></tr>
<tr><td></td><td>Lab Experiment List

1. Variation of magnetic field along the axis of single coil
2. Variation of magnetic field along the axis of Helmholtz coil
3. Ballistic Galvanometer: Ballistic constant, current sensitivity and voltage sensitivity
4. Ballistic Galvanometer: High resistance by Leakage method
5. Ballistic Galvanometer: Low resistance by Kelvin's double bridge method
6. Ballistic Galvanometer: Self inductance of a coil by Rayleigh's method
7. Ballistic Galvanometer: Comparison of capacitances
8. Carey Foster Bridge: Resistance per unit length and low resistance
9. Deflection and Vibration Magnetometer: Magnetic moment of a magnet and horizontal component of earth's magnetic field
10. Earth Inductor: Horizontal component of earth's magnetic field

Online Virtual Lab Experiment List / Link

Virtual Labs at Amrita Vishwa Vidyapeetham
https://vlab.amrita.edu/?sub=1&brch=192

1. Tangent galvanometer
2. Magnetic field along the axis of a circular coil carrying current
3. Deflection magnetometer
4. Van de Graaff generator
5. Barkhausen effect
6. Temperature coefficient of resistance
7. Anderson's bridge
8. Quincke's method</td><td>60</td></tr>
</table>

Suggested Readings

1. B.L. Worsnop, H.T. Flint, "Advanced Practical Physics for Students", Methuen & Co., Ltd., London, 1962, 9e
2. S. Panigrahi, B. Mallick, "Engineering Practical Physics", Cengage Learning India Pvt. Ltd., 2015, 1e
3. Lab Experiment Manuals

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual Universities.

Suggestive Digital Platforms / Web Links

1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=192
2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities.

Course Prerequisites

As per University Guidelines

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

-NA-

Suggested Continuous Internal Evaluation (CIE) Methods

-NA-

Suggested Equivalent Online Courses

Further Suggestions

- The institution may add / modify / change the experiments of the same standard in the subject.
- The institution may suggest a minimum number of experiments (say 6) to be performed by each student per semester from the Lab Experiment List.
- The institution may suggest a minimum number of experiments (say 3) to be performed by each student per semester from the Online Virtual Lab Experiment List / Link.

Programme/Class: **Diploma**	Year: **Second (2nd)**	Semester: **Fourth (IV)**
Subject: **Physics**		
Course Code: **B010401T**	Course Title: **Perspectives of Modern Physics & Basic Electronics**	

Course Outcomes (COs)

1. Recognize the difference between the structure of space & time in Newtonian & Relativistic mechanics.
2. Understand the physical significance of consequences of Lorentz transformation equations.
3. Comprehend the wave-particle duality.
4. Develop an understanding of the foundational aspects of Quantum Mechanics.
5. Understand the comparison between various biasing techniques.
6. Understand the classification of amplifiers.
7. Comprehend the use of feedback and oscillators.
8. Comprehend the theory and working of optical fibers along with its applications.

Credits: **4**	Core Compulsory (Major) / Elective (Minor)
Max. Marks: **25 (CIE) + 75 (University Exam)**	Min. Passing Marks: As per University Norms

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

Unit	Topics	No. of Lectures
	PART A **Perspectives of Modern Physics**	
I	**Relativity-Experimental Background** Structure of space & time in Newtonian mechanics and inertial & non-inertial frames. Galilean transformations. Newtonian relativity. Galilean transformation and Electromagnetism. Attempts to locate the Absolute Frame: Michelson-Morley experiment and significance of the null result. Einstein's postulates of special theory of relativity.	7
II	**Relativity-Relativistic Kinematics** Structure of space & time in Relativistic mechanics and derivation of Lorentz transformation equations (4-vector formulation included). Consequences of Lorentz Transformation Equations (derivations & examples included): Transformation of Simultaneity (Relativity of simultaneity); Transformation of Length (Length contraction); Transformation of Time (Time dilation); Transformation of Velocity (Relativistic velocity addition); Transformation of Acceleration; Transformation of Mass (Variation of mass with velocity). Relation between Energy & Mass (Einstein's mass & energy relation) and Energy & Momentum.	8
III	**Inadequacies of Classical Mechanics** Particle Properties of Waves: Spectrum of Black Body radiation, Photoelectric effect, Compton effect and their explanations based on Max Planck's Quantum hypothesis. Wave Properties of Particles: Louis de Broglie's hypothesis of matter waves and their experimental verification by Davisson-Germer's experiment and Thomson's experiment.	8
IV	**Introduction to Quantum Mechanics** Matter Waves: Mathematical representation, Wavelength, Concept of Wave group, Group (particle) velocity, Phase (wave) velocity and relation between Group & Phase velocities. Wave Function: Functional form, Normalisation of wave function, Orthogonal & Orthonormal wave functions and Probabilistic interpretation of wave function based on Born Rule.	7

PART B

Basic Electronics & Introduction to Fiber Optics

V	**Transistor Biasing** Faithful amplification & need for biasing. Stability Factors and its calculation for transistor biasing circuits for CE configuration: Fixed Bias (Base Resistor Method), Emitter Bias (Fixed Bias with Emitter Resistor), Collector to Base Bias (Base Bias with Collector Feedback) &, Voltage Divider Bias. Discussion of Emitter-Follower configuration.	7
VI	**Amplifiers** Classification of amplifiers based on Mode of operation (Class A, B, AB, C & D), Stages (single & multi stage, cascade & cascode connections), Coupling methods (RC, Transformer, Direct & LC couplings), Nature of amplification (Voltage & Power amplification) and Frequency capabilities (AF, IF, RF & VF). Theory & working of RC coupled voltage amplifier (Uses of various resistors & capacitors, and Frequency response) and Transformer coupled power amplifier (calculation of Power, Effect of temperature, Use of heat sink & Power dissipation). Calculation of Amplifier Efficiency (power efficiency) for Class A Series-Fed, Class A Transformer Coupled, Class B Series-Fed and Class B Transformer Coupled amplifiers.	7
VII	**Feedback & Oscillator Circuits** Feedback Circuits: Effects of positive and negative feedback. Voltage Series, Voltage Shunt, Current Series and Current Shunt feedback connection types and their uses for specific amplifiers. Estimation of Input Impedance, Output Impedance, Gain, Stability, Distortion, Noise and Band Width for Voltage Series negative feedback and their comparison between different negative feedback connection types. Oscillator Circuits: Use of positive feedback for oscillator operation. Barkhausen criterion for self-sustained oscillations. Feedback factor and frequency of oscillation for RC Phase Shift oscillator and Wein Bridge oscillator. Qualitative discussion of Reactive Network feedback oscillators (Tuned oscillator circuits): Hartley & Colpitt oscillators.	8
VIII	**Introduction to Fiber Optics** Basics of Fiber Optics, step index fiber, graded index fiber, light propagation through an optical fiber, acceptance angle & numerical aperture. Qualitative discussion of fiber losses (bending & intrinsic), fiber connectors (jointing & couplers) Applications of optical fibers (block diagram of optical fiber communication system with qualitative discussion of each section).	8

Suggested Readings

PART A

1. A. Beiser, Shobhit Mahajan, "Concepts of Modern Physics: Special Indian Edition", McGraw Hill, 2009, 6e
2. John R. Taylor, Chris D. Zafiratos, Michael A.Dubson, "Modern Physics for Scientists and Engineers", Prentice-Hall of India Private Limited, 2003, 2e
3. R.A. Serway, C.J. Moses, and C.A. Moyer, "Modern Physics", Cengage Learning India Pvt. Ltd, 2004, 3e
4. R. Resnick, "Introduction to Special Relativity", Wiley India Private Limited, 2007
5. R. Murugeshan, Kiruthiga Sivaprasath, "Modern Physics", S. Chand Publishing, 2019, 18e

PART B

1. R.L. Boylestad, L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice-Hall of India Pvt. Ltd., 2015, 11e
2. J. Millman, C.C. Halkias, Satyabrata Jit, "Electronic Devices and Circuits", McGraw Hill, 2015, 4e
3. B.G. Streetman, S.K. Banerjee, "Solid State Electronic Devices", Pearson Education India, 2015, 7e
4. J.D. Ryder, "Electronic Fundamentals and Applications", Prentice-Hall of India Private Limited, 1975, 5e
5. John M. Senior, "Optical Fiber Communications: Principles and Practice", Pearson Education Limited, 2010, 3e
6. John Wilson, John Hawkes, "Optoelectronics: Principles and Practice", Pearson Education Limited, 2018, 3e
7. S.L. Gupta, V. Kumar, "Hand Book of Electronics", Pragati Prakashan, Meerut, 2016, 43e

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual 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

Course Prerequisites

As per University Guidelines

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

Faculty of Science

Suggested Continuous Internal Evaluation (CIE) Methods

20 marks for Test / Quiz / Assignment / Seminar
05 marks for Class Interaction

Suggested Equivalent Online Courses

1. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy
4. edX, https://www.edx.org/course/subject/physics
5. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/

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 Examinations, equal weightage should be given to Part A (units I to IV) and Part B (units V to VIII) while framing the questions.**

Programme/Class: **Diploma**	Year: **Second (2nd)**	Semester: **Fourth (IV)**
Subject: **Physics**		
Course Code: **B010402P**	Course Title: **Basic Electronics Instrumentation**	

Course Outcomes (COs)

Basic Electronics instrumentation has the most striking impact on the industry wherever the components / instruments are used to study and determine the electronic properties. Measurement precision and perfection is achieved through Lab Experiments. Online Virtual Lab Experiments give an insight in simulation techniques and provide a basis for modeling.

Credits: **2**	Core Compulsory (Major)
Max. Marks: **100 (University Exam)**	Min. Passing Marks: As per University Norms

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

Unit	Topics	No. of Lectures
	Lab Experiment List	60
	1. Transistor Bias Stability 2. Comparative Study of CE, CB and CC amplifier 3. Clippers and Clampers 4. Study of Emitter Follower 5. Frequency response of single stage RC coupled amplifier 6. Frequency response of single stage Transformer coupled amplifier 7. Effect of negative feedback on frequency response of RC coupled amplifier 8. Study of Schmitt Trigger 9. Study of Hartley oscillator 10. Study of Wein Bridge oscillator	
	Online Virtual Lab Experiment List / Link	
	Virtual Labs an initiative of MHRD Govt. of India http://vlabs.iitkgp.ac.in/psac/# 1. Diode as Clippers 2. Diode as Clampers 3. BJT as switch and Load Lines Virtual Labs an initiative of MHRD Govt. of India http://vlabs.iitkgp.ac.in/be/# 4. RC frequency response Virtual Labs at Amrita Vishwa Vidyapeetham https://vlab.amrita.edu/index.php?sub=1&brch=201 5. Hartley oscillator 6. Colpitt oscillator	

Virtual Labs at Amrita Vishwa Vidyapeetham
http://vlab.amrita.edu/index.php?sub=59&brch=269

7. Fiber Optic Analog and Digital Link
8. Fiber Optic Bi-directional Communication
9. Wavelength Division Multiplexing
10. Measurement of Bending Losses in Optical Fiber
11. Measurement of Numerical Aperture
12. Study of LED and Detector Characteristics

Suggested Readings

1. R.L. Boylestad, L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice-Hall of India Pvt. Ltd., 2015, 11e
2. J. Millman, C.C. Halkias, Satyabrata Jit, "Electronic Devices and Circuits", McGraw Hill, 2015, 4e
3. B.G. Streetman, S.K. Banerjee, "Solid State Electronic Devices", Pearson Education India, 2015, 7e
4. J.D. Ryder, "Electronic Fundamentals and Applications", Prentice-Hall of India Private Limited, 1975, 5e
5. John M. Senior, "Optical Fiber Communications: Principles and Practice", Pearson Education Limited, 2010, 3e
6. John Wilson, John Hawkes, "Optoelectronics: Principles and Practice", Pearson Education Limited, 2018, 3e
7. S.L. Gupta, V. Kumar, "Hand Book of Electronics", Pragati Prakashan, Meerut, 2016, 43e
8. Lab Experiment Manuals

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual Universities.

Suggestive Digital Platforms / Web Links

1. Virtual Labs an initiative of MHRD Govt. of India, http://vlabs.iitkgp.ac.in/psac/#
2. Virtual Labs an initiative of MHRD Govt. of India, http://vlabs.iitkgp.ac.in/be/#
3. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/index.php?sub=1&brch=201
4. Virtual Labs at Amrita Vishwa Vidyapeetham, http://vlab.amrita.edu/index.php?sub=59&brch=269
5. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities.

Course Prerequisites

As per University Guidelines

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

-NA-

Suggested Continuous Internal Evaluation (CIE) Methods

-NA-

Suggested Equivalent Online Courses

Further Suggestions

- The institution may add / modify / change the experiments of the same standard in the subject.
- The institution may suggest a minimum number of experiments (say 6) to be performed by each student per semester from the Lab Experiment List.
- The institution may suggest a minimum number of experiments (say 3) to be performed by each student per semester from the Online Virtual Lab Experiment List / Link.

V.Singh

Programme/Class: **Diploma**	Year: **Second (2^{nd})**	Semester: **Fourth (IV)**
Subject: **Physics**		
Course Code: **B010403R**	Course Title: **Research Project in Physics**	

Course Outcomes (COs)

1. Exposure to research through supervised Research project.
2. Discipline-specific expertise, like self-directed scientific literature analysis, and apply it to pursue their research career.

Credits: **3**	Core Compulsory (Major)
Max. Marks: **100 (University Exam)**	Min. Passing Marks: As per University Norms

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **0-6-0**

Unit	**Topics**	**No. of Lectures**
	The Research Project in Physics will be based upon the guidelines laid by the University.	90

Suggested Readings

Research Project Topic related Books, Articles, Research Papers, etc.

Suggestive Digital Platforms / Web Links

Course Prerequisites

As per University Guidelines

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

-NA-

Suggested Continuous Internal Evaluation (CIE) Methods

-NA-

Suggested Equivalent Online Courses

Further Suggestions

Research Project thrust area / topic should be preferably based upon the mutual consent of the mentor and mentee.

DETAILED PHYSICS SYLLABUS
FOR
THIRD YEAR
OF HIGHER EDUCATION

YEAR	SEME-STER	PAPER	PAPER TITLE	UNIT TITLE (Periods Per Semester)
DEGREE IN BACHELOR OF SCIENCE				
THIRD YEAR	SEMESTER V	Theory Paper-1	**Classical & Statistical Mechanics** Part A: Introduction to Classical Mechanics Part B: Introduction to Statistical Mechanics	**Part A** I: Constrained Motion (6) II: Lagrangian Formalism (9) III: Hamiltonian Formalism (8) IV: Central Force (7) **Part B** V: Macrostate & Microstate (6) VI: Concept of Ensemble (6) VII: Distribution Laws (10) VIII: Applications of Statistical Distribution Laws (8)
		Theory Paper-2	**Quantum Mechanics & Spectroscopy** Part A: Introduction to Quantum Mechanics Part B: Introduction to Spectroscopy	**Part A** I: Operator Formalism (5) II: Eigen & Expectation Values (6) III: Uncertainty Principle & Schrodinger Equation (7) IV: Applications of Schrodinger Equation (12) **Part B** V: Vector Atomic Model (10) VI: Spectra of Alkali & Alkaline Elements (6) VII: X-Rays & X-Ray Spectra (7) VIII: Molecular Spectra (7)
		Practical Paper	**Demonstrative Aspects of Optics & Lasers**	Lab Experiment List Online Virtual Lab Experiment List/Link
	SEMESTER VI	Theory Paper-1	**Solid State & Nuclear Physics** Part A: Introduction to Solid State Physics Part B: Introduction to Nuclear Physics	**Part A** I: Crystal Structure (7) II: Crystal Diffraction (7) III: Crystal Bindings (7) IV: Lattice Vibrations (9) **Part B** V: Nuclear Forces & Radioactive Decays (9) VI: Nuclear Models & Nuclear Reactions (9) VII: Accelerators & Detectors (6) VIII: Elementary Particles (6)
		Theory Paper-2	**Analog & Digital Principles & Applications** Part A: Analog Electronic Circuits Part B: Digital Electronics	**Part A** I: Semiconductor Junction (9) II: Transistor Modeling (8) III: Field Effect Transistors (8) IV: Other Devices (5) **Part B** V: Number System (6) VI: Binary Arithmetic (5) VII: Logic Gates (9) VIII: Combinational & Sequential Circuits (10)
		Practical Paper	**Analog & Digital Circuits**	Lab Experiment List Online Virtual Lab Experiment List/Link

Programme/Class: **Degree**	Year: **Third (3rd)**	Semester: **Fifth (V)**
Subject: **Physics**		
Course Code: **B010501T**	Course Title: **Classical & Statistical Mechanics**	

Course Outcomes (COs)

1. Understand the concepts of generalized coordinates and D'Alembert's principle.
2. Understand the Lagrangian dynamics and the importance of cyclic coordinates.
3. Comprehend the difference between Lagrangian and Hamiltonian dynamics.
4. Understand the important features of central force and its application in Kepler's problem.
5. Recognize the difference between macrostate and microstate.
6. Comprehend the concept of ensembles.
7. Understand the classical and quantum statistical distribution laws.
8. Understand the applications of statistical distribution laws.

Credits: **4**	Core Compulsory (Major) / Elective (Minor)
Max. Marks: **25 (CIE) + 75 (University Exam)**	Min. Passing Marks: As per University Norms

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

Unit	Topics	No. of Lectures
	PART A **Introduction to Classical Mechanics**	
I	**Constrained Motion** Constraints - Definition, Classification and Examples. Degrees of Freedom and Configuration space. Constrained system, Forces of constraint and Constrained motion. Generalised coordinates, Transformation equations and Generalised notations & relations. Principle of Virtual work and D'Alembert's principle.	6
II	**Lagrangian Formalism** Lagrangian for conservative & non-conservative systems, Lagrange's equation of motion (no derivation), Comparison of Newtonian & Lagrangian formulations, Cyclic coordinates, and Conservation laws (with proofs and properties of kinetic energy function included). Simple examples based on Lagrangian formulation.	9
III	**Hamiltonian Formalism** Phase space, Hamiltonian for conservative & non-conservative systems, Physical significance of Hamiltonian, Hamilton's equation of motion (no derivation), Comparison of Lagrangian & Hamiltonian formulations, Cyclic coordinates, and Construction of Hamiltonian from Lagrangian. Simple examples based on Hamiltonian formulation.	8
IV	**Central Force** Definition and properties (with prove) of central force. Equation of motion and differential equation of orbit. Bound & unbound orbits, stable & non-stable orbits, closed & open orbits and Bertrand's theorem. Motion under inverse square law of force and derivation of Kepler's laws. Laplace-Runge-Lenz vector (Runge-Lenz vector) and its applications.	7

PART B

Introduction to Statistical Mechanics

V	**Macrostate & Microstate** Macrostate, Microstate, Number of accessible microstates and Postulate of equal a priori. Phase space, Phase trajectory, Volume element in phase space, Quantisation of phase space and number of accessible microstates for free particle in 1D, free particle in 3D & harmonic oscillator in 1D.	6
VI	**Concept of Ensemble** Problem with time average, concept of ensemble, postulate of ensemble average and Liouville's theorem (proof included). Micro Canonical, Canonical & Grand Canonical ensembles. Thermodynamic Probability. Postulate of Equilibrium and Boltzmann Entropy relation.	6
VII	**Distribution Laws** Statistical Distribution Laws: Expressions for number of accessible microstates, probability & number of particles in i^{th} state at equilibrium for Maxwell-Boltzmann, Bose-Einstein & Fermi-Dirac statistics. Comparison of statistical distribution laws and their physical significance. Canonical Distribution Law: Boltzmann's Canonical Distribution Law, Boltzmann's Partition Function, Proof of Equipartition Theorem (Law of Equipartition of energy) and relation between Partition function and Thermodynamic potentials.	10
VIII	**Applications of Statistical Distribution Laws** Application of Bose-Einstein Distribution Law: Photons in a black body cavity and derivation of Planck's Distribution Law. Application of Fermi-Dirac Distribution Law: Free electrons in a metal, Definition of Fermi energy, Determination of Fermi energy at absolute zero, Kinetic energy of Fermi gas at absolute zero and concept of Density of States (Density of Orbitals).	8

Suggested Readings

PART A

1. Herbert Goldstein, Charles P. Poole, John L. Safko, "Classical Mechanics", Pearson Education, India, 2011, 3e
2. N.C. Rana, P.S. Joag, "Classical Mechanics", McGraw Hill, 2017
3. R.G. Takwale, P.S. Puranik, "Introduction to Classical Mechanics", McGraw Hill, 2017

PART B

1. F. Reif, "Statistical Physics (In SI Units): Berkeley Physics Course Vol 5", McGraw Hill, 2017, 1e
2. B.B. Laud, "Fundamentals of Statistical Mechanics", New Age International Private Limited, 2020, 2e
3. B.K. Agarwal, M. Eisner, "Statistical Mechanics", New Age International Private Limited, 2007, 2e

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual 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

Course Prerequisites

As per University Guidelines

This course can be opted as an Elective by the students of following subjects
Faculty of Science
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar 05 marks for Class Interaction
Suggested Equivalent Online Courses
1. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html 3. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 4. edX, https://www.edx.org/course/subject/physics 5. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/
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 Examinations, equal weightage should be given to Part A (units I to IV) and Part B (units V to VIII) while framing the questions.**

Programme/Class: **Degree**	Year: **Third (3^{rd})**	Semester: **Fifth (V)**
Subject: **Physics**		
Course Code: **B010502T**	Course Title: **Quantum Mechanics & Spectroscopy**	

Course Outcomes (COs)

1. Understand the significance of operator formalism in Quantum mechanics.
2. Understand the eigen and expectation value methods.
3. Understand the basis and interpretation of Uncertainty principle.
4. Develop the technique of solving Schrodinger equation for 1D and 3D problems.
5. Comprehend the success of Vector atomic model in the theory of Atomic spectra.
6. Comprehend the different aspects of spectra of Group I & II elements.
7. Understand the production and applications of X-rays.
8. Develop an understanding of the fundamental aspects of Molecular spectra.

Credits: **4**	Core Compulsory (Major) / Elective (Minor)
Max. Marks: **25 (CIE) + 75 (University Exam)**	Min. Passing Marks: As per University Norms
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**	

Unit	Topics	No. of Lectures
	PART A **Introduction to Quantum Mechanics**	
I	**Operator Formalism** Operators: Review of matrix algebra, definition of an operator, special operators, operator algebra and operators corresponding to various physical-dynamical variables. Commutators: Definition, commutator algebra and commutation relations among position, linear momentum & angular momentum and energy & time. Simple problems based on commutation relations.	5
II	**Eigen & Expectation Values** Eigen & Expectation Values: Eigen equation for an operator, eigen state (value) and eigen functions. Linear superposition of eigen functions and Non-degenerate & Degenerate eigen states. Expectation value pertaining to an operator and its physical interpretation. Hermitian Operators: Definition, properties and applications. Prove of the hermitian nature of various physical-dynamical operators.	6
III	**Uncertainty Principle & Schrodinger Equation** Uncertainty Principle: Commutativity & simultaneity (theorems with proofs). Non commutativity of operators as the basis for uncertainty principle and derivation of uncertainty principle through Schwarz inequality. Uncertainty principle for various conjugate pairs of physical-dynamical parameters and its applications. Schrodinger Equation: Derivation of time independent & time dependent forms, Schrodinger equation as an eigen equation, Deviation & interpretation of equation of continuity in Schrodinger representation, and Equation of motion of an operator in Schrodinger representation.	7

IV	**Applications of Schrodinger Equation** Application to 1D Problems: Infinite Square well potential (Particle in 1D box), Finite Square well potential, Potential step, Rectangular potential barrier and 1D Harmonic oscillator. Application to 3D Problems: Infinite Square well potential (Particle in a 3D box) and the Hydrogen atom (radial distribution function and radial probability included). (Direct solutions of Hermite, Associated Legendre and Associated Laguerre differential equations to be substituted).	12
	PART B **Introduction to Spectroscopy**	
V	**Vector Atomic Model** Inadequacies of Bohr and Bohr-Sommerfeld atomic models w.r.t. spectrum of Hydrogen atom (fine structure of H-alpha line). Modification due to finite mass of nucleus and Deuteron spectrum. Vector atomic model (Stern-Gerlach experiment included) and physical & geometrical interpretations of various quantum numbers for single & many valence electron systems. LS & jj couplings, spectroscopic notation for energy states, selection rules for transition of electrons and intensity rules for spectral lines. Fine structure of H-alpha line on the basis of vector atomic model.	10
VI	**Spectra of Alkali & Alkaline Elements** Spectra of alkali elements: Screening constants for s, p, d & f orbitals; sharp, principle, diffuse & fundamental series; doublet structure of spectra and fine structure of Sodium D line. Spectra of alkaline elements: Singlet and triplet structure of spectra.	6
VII	**X-Rays & X-Ray Spectra** Nature & production, Continuous X-ray spectrum & Duane-Hunt's law, Characteristic X-ray spectrum & Mosley's law, Fine structure of Characteristic X-ray spectrum, and X-ray absorption spectrum.	7
VIII	**Molecular Spectra** Discrete set of energies of a molecule, electronic, vibrational and rotational energies. Quantisation of vibrational energies, transition rules and pure vibrational spectra. Quantisation of rotational energies, transition rules, pure rotational spectra and determination of inter nuclear distance. Rotational-Vibrational spectra; transition rules; fundamental band & hot band; O, P, Q, R, S branches.	7

Suggested Readings

PART A

1. D.J. Griffiths, "Introduction to Quantum Mechanics", Pearson Education, India, 2004, 2e
2. E. Wichmann, "Quantum Physics (In SI Units): Berkeley Physics Course Vol 4", McGraw Hill, 2017
3. Richard P. Feynman, Robert B. Leighton, Matthew Sands, "The Feynman Lectures on Physics - Vol. 3", Pearson Education Limited, 2012
4. R Murugeshan, Kiruthiga Sivaprasath, "Modern Physics", S. Chand Publishing, 2019, 18e

PART B

1. H.E. White, "Introduction to Atomic Spectra", McGraw Hill, 1934
2. C.N. Banwell, E.M. McCash, "Fundamentals of Molecular Spectroscopy", McGraw Hill, 2017, 4e
3. R Murugeshan, Kiruthiga Sivaprasath, "Modern Physics", S. Chand Publishing, 2019, 18e
4. S.L. Gupta, V. Kumar, R.C. Sharma, "Elements of Spectroscopy", Pragati Prakashan, Meerut, 2015, 27e

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual 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
Course Prerequisites
As per University Guidelines
This course can be opted as an Elective by the students of following subjects
Faculty of Science
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar 05 marks for Class Interaction
Suggested Equivalent Online Courses
1. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html 3. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 4. edX, https://www.edx.org/course/subject/physics 5. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/
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 Examinations, equal weightage should be given to Part A (units I to IV) and Part B (units V to VIII) while framing the questions.**

Programme/Class: **Degree**	Year: **Third (3^{rd})**	Semester: **Fifth (V)**
Subject: **Physics**		
Course Code: **B010503P**	Course Title: **Demonstrative Aspects of Optics & Lasers**	
Course Outcomes (COs)		
Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the optical properties. Measurement precision and perfection is achieved through Lab Experiments. Online Virtual Lab Experiments give an insight in simulation techniques and provide a basis for modeling.		
Credits: 2	Core Compulsory (Major)	
Max. Marks: **100 (University Exam)**	Min. Passing Marks: As per University Norms	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **0-0-4**		

Unit	Topics	No. of Lectures
	Lab Experiment List 1. Fresnel Biprism: Wavelength of sodium light 2. Fresnel Biprism: Thickness of mica sheet) 3. Newton's Rings: Wavelength of sodium light 4. Newton's Rings: Refractive index of liquid 5. Plane Diffraction Grating: Resolving power 6. Plane Diffraction Grating: Spectrum of mercury light 7. Spectrometer: Refractive index of the material of a prism using sodium light 8. Spectrometer: Dispersive power of the material of a prism using mercury light 9. Polarimeter: Specific rotation of sugar solution 10. Wavelength of Laser light using diffraction by single slit **Online Virtual Lab Experiment List / Link** Virtual Labs at Amrita Vishwa Vidyapeetham https://vlab.amrita.edu/?sub=1&brch=189 1. Michelson's Interferometer 2. Michelson's Interferometer: Wavelength of laser beam 3. Newton's Rings: Wavelength of light 4. Newton's Rings: Refractive index of liquid 5. Brewster's angle determination 6. Laser beam divergence and spot size Virtual Labs at Amrita Vishwa Vidyapeetham https://vlab.amrita.edu/index.php?sub=1&brch=281 7. Spectrometer: Refractive index of the material of a prism 8. Spectrometer: Dispersive power of a prism 9. Spectrometer: Determination of Cauchy's constants 10. Diffraction Grating	60

Suggested Readings

1. B.L. Worsnop, H.T. Flint, "Advanced Practical Physics for Students", Methuen & Co., Ltd., London, 1962, 9e
2. S. Panigrahi, B. Mallick, "Engineering Practical Physics", Cengage Learning India Pvt. Ltd., 2015, 1e
3. Lab Experiment Manuals

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual Universities.

Suggestive Digital Platforms / Web Links

1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=189
2. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/index.php?sub=1&brch=281
3. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities.

Course Prerequisites

As per University Guidelines

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

-NA-

Suggested Continuous Internal Evaluation (CIE) Methods

-NA-

Suggested Equivalent Online Courses

Further Suggestions

- The institution may add / modify / change the experiments of the same standard in the subject.
- The institution may suggest a minimum number of experiments (say 6) to be performed by each student per semester from the Lab Experiment List.
- The institution may suggest a minimum number of experiments (say 3) to be performed by each student per semester from the Online Virtual Lab Experiment List / Link.

<table>
<tr><td>Programme/Class: Degree</td><td colspan="2">Year: Third (3rd)</td><td>Semester: Sixth (VI)</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course Code: B010601T</td><td colspan="3">Course Title: Solid State & Nuclear Physics</td></tr>
<tr><td colspan="4">Course Outcomes (COs)</td></tr>
<tr><td colspan="4">1. Understand the crystal geometry w.r.t. symmetry operations.
2. Comprehend the power of X-ray diffraction and the concept of reciprocal lattice.
3. Understand various properties based on crystal bindings.
4. Recognize the importance of Free Electron & Band theories in understanding the crystal properties.
5. Understand the salient features of nuclear forces & radioactive decays.
6. Understand the importance of nuclear models & nuclear reactions.
7. Comprehend the working and applications of nuclear accelerators and detectors.
8. Understand the classification and properties of basic building blocks of nature.</td></tr>
<tr><td colspan="2">Credits: 4</td><td colspan="2">Core Compulsory (Major) / Elective (Minor)</td></tr>
<tr><td colspan="2">Max. Marks: 25 (CIE) + 75 (University Exam)</td><td colspan="2">Min. Passing Marks: As per University Norms</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0</td></tr>
<tr><td>Unit</td><td colspan="2">Topics</td><td>No. of Lectures</td></tr>
<tr><td colspan="4"><u>PART A</u>
Introduction to Solid State Physics</td></tr>
<tr><td>I</td><td colspan="2">Crystal Structure
Lattice, Basis & Crystal structure. Lattice translation vectors, Primitive & non-primitive cells. Symmetry operations, Point group & Space group. 2D & 3D Bravais lattice. Parameters of cubic lattices. Lattice planes and Miller indices. Simple crystal structures - HCP & FCC, Diamond, Cubic Zinc Sulphide, Sodium Chloride, Cesium Chloride and Glasses.</td><td>7</td></tr>
<tr><td>II</td><td colspan="2">Crystal Diffraction
X-ray diffraction and Bragg's law. Experimental diffraction methods - Laue, Rotating crystal and Powder methods. Derivation of scattered wave amplitude. Reciprocal lattice, Reciprocal lattice vectors and relation between Direct & Reciprocal lattice. Diffraction conditions, Ewald's method and Brillouin zones. Reciprocal lattice to SC, BCC & FCC lattices. Atomic Form factor and Crystal Structure factor.</td><td>7</td></tr>
<tr><td>III</td><td colspan="2">Crystal Bindings
Classification of Crystals on the Basis of Bonding - Ionic, Covalent, Metallic, van der Waals (Molecular) and Hydrogen bonded. Crystals of inert gases, Attractive interaction (van der Waals-London) & Repulsive interaction, Equilibrium lattice constant, Cohesive energy and Compressibility & Bulk modulus. Ionic crystals, Cohesive energy, Madelung energy and evaluation of Madelung constant.</td><td>7</td></tr>
</table>

IV	**Lattice Vibrations** Lattice Vibrations: Lattice vibrations for linear mono & di atomic chains, Dispersion relations and Acoustical & Optical branches (qualitative treatment). Qualitative description of Phonons in solids. Lattice heat capacity, Dulong-Petit's law and Einstein's theory of lattice heat capacity. Free Electron Theory: Fermi energy, Density of states, Heat capacity of conduction electrons, Paramagnetic susceptibility of conduction electrons and Hall effect in metals. Band Theory: Origin of band theory, Qualitative idea of Bloch theorem, Kronig-Penney model, Effectice mass of an electron & Concept of Holes & Classification of solids on the basis of band theory.	9
	PART B **Introduction to Nuclear Physics**	
V	**Nuclear Forces & Radioactive Decays** General Properties of Nucleus: Mass, binding energy, radii, density, angular momentum, magnetic dipole moment vector and electric quadrupole moment tensor. Nuclear Forces: General characteristic of nuclear force and Deuteron ground state properties. Radioactive Decays: Nuclear stability, basic ideas about beta minus decay, beta plus decay, alpha decay, gamma decay & electron capture, fundamental laws of radioactive disintegration and radioactive series.	9
VI	**Nuclear Models & Nuclear Reactions** Nuclear Models: Liquid drop model and Bethe-Weizsacker mass formula. Single particle shell model (the level scheme in the context of reproduction of magic numbers included). Nuclear Reactions: Bethe's notation, types of nuclear reaction, Conservation laws, Cross-section of nuclear reaction, Theory of nuclear fission (qualitative), Nuclear reactors and Nuclear fusion.	9
VII	**Accelerators & Detectors** Accelerators: Theory, working and applications of Van de Graaff accelerator, Cyclotron and Synchrotron. Detectors: Theory, working and applications of GM counter, Semiconductor detector, Scintillation counter and Wilson cloud chamber.	6
VIII	**Elementary Particles** Fundamental interactions & their mediating quanta. Concept of antiparticles. Classification of elementary particles based on intrinsic-spin, mass, interaction & lifetime. Families of Leptons, Mesons, Baryons & Baryon Resonances. Conservation laws for mass-energy, linear momentum, angular momentum, electric charge, baryonic charge & leptonic charge.	6

Suggested Readings

PART A

1. Charles Kittel, "Introduction to Solid State Physics", Wiley India Private Limited, 2012, 8e
2. A.J. Dekker, "Solid State Physics", Macmillan India Limited, 1993
3. R.K. Puri, V.K. Babbar, "Solid State Physics", S. Chand Publishing, 2015

PART B

1. Kenneth S. Krane, "Introductory Nuclear Physics", Wiley India Private Limited, 2008
2. Bernard L. Cohen, "Concepts of Nuclear Physics", McGraw Hill, 2017
3. S.N. Ghoshal, "Nuclear Physics", S. Chand Publishing, 2019

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual 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
Course Prerequisites
As per University Guidelines
This course can be opted as an Elective by the students of following subjects
Faculty of Science
Suggested Continuous Internal Evaluation (CIE) Methods
20 marks for Test / Quiz / Assignment / Seminar 05 marks for Class Interaction
Suggested Equivalent Online Courses
1. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html 3. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 4. edX, https://www.edx.org/course/subject/physics 5. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/
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 Examinations, equal weightage should be given to Part A (units I to IV) and Part B (units V to VIII) while framing the questions.**

Programme/Class: **Degree**	Year: **Third (3rd)**	Semester: **Sixth (VI)**
Subject: **Physics**		
Course Code: **B010602T**	Course Title: **Analog & Digital Principles & Applications**	

Course Outcomes (COs)

1. Understand the drift and diffusion of charge carriers in a semiconductor.
2. Understand the Two-Port model of a transistor.
3. Comprehend the working, properties and uses of FETs.
4. Comprehend the design and operations of SCRs and UJTs.
5. Understand various number systems and binary codes.
6. Familiarize with binary arithmetic.
7. Understand the working and properties of various logic gates.
8. Comprehend the design of combinational and sequential circuits.

Credits: 4	Core Compulsory (Major) / Elective (Minor)
Max. Marks: **25 (CIE) + 75 (University Exam)**	Min. Passing Marks: As per University Norms

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

Unit	Topics	No. of Lectures
	PART A **Analog Electronic Circuits**	
I	**Semiconductor Junction** Expressions for Fermi energy, Electron density in conduction band, Hole density in valence band. Drift of charge carriers (mobility & conductivity), Diffusion of charge carries and Life time of charge carries in a semiconductor. Work function in metals and semiconductors. Expressions for Barrier potential, Barrier width and Junction capacitance (diffusion & transition) for depletion layer in a PN junction. Expressions for Current (diode equation) and Dynamic resistance for PN junction.	9
II	**Transistor Modeling** Transistor as Two-Port Network. Notation for dc & ac components of voltage & current. Quantitative discussion of Z, Y & h parameters and their equivalent two-generator model circuits. h-parameters for CB, CE & CC configurations. Analysis of transistor amplifier using the hybrid equivalent model and estimation of Input Impedance, Output Impedance and Gain (current, voltage & power).	8
III	**Field Effect Transistors** JFET: Construction (N channel & P channel); Configuration (CS, CD & CG); Operation in different regions (Ohmic or Linear, Saturated or Active or Pinch off & Break down); Important Terms (Shorted Gate Drain Current, Pinch Off Voltage & Gate Source Cut-Off Voltage); Expression for Drain Current (Shockley equation); Characteristics (Drain & Transfer); Parameters (Drain Resistance, Mutual Conductance or Transconductance & Amplification Factor); Biasing w.r.t. CS configuration (Self Bias & Voltage Divider Bias); Amplifiers (CS & CD or Source Follower); Comparison (N & P channels and BJTs & JFETs). MOSFET: Construction and Working of DE-MOSFET (N channel & P channel) and E-MOSFET (N channel & P channel); Characteristics (Drain & Transfer) of DE-MOSFET and E-MOSFET; Comparison of JFFET and MOSFET.	8

IV	**Other Devices** SCR: Construction; Equivalent Circuits (Two Diodes, Two Transistors & One Diode-One Transistor); Working (Off state & On state); Characteristics; Applications (Static switch, Phase control system & Battery charger). UJT: Construction; Equivalent Circuit; Working (Cutoff, Negative Resistance & Saturation regions); Characteristics (Peak & Valley points); Applications (Trigger circuits, Relaxation oscillators & Sawtooth generators).	5
	PART B **Digital Electronics**	
V	**Number System** Number Systems: Binary, Octal, Decimal & Hexadecimal number systems and their inter conversion. Binary Codes: BCD, Excess-3 (XS3), Parity, Gray, ASCII & EBCDIC Codes and their advantages & disadvantages. Data representation.	6
VI	**Binary Arithmetic** Binary Addition, Decimal Subtraction using 9's & 10's complement, Binary Subtraction using 1's & 2's compliment, Multiplication and Division.	5
VII	**Logic Gates** Truth Table, Symbolic Representation and Properties of OR, AND, NOT, NOR, NAND, XOR & XNOR Gates. Implementation of OR, AND & NOT gates (realization using diodes & transistor). De Morgan's theorems. NOR & NAND gates as Universal Gates. Application of XOR & XNOR gates as parity checker. Boolean Algebra. Karnaugh Map.	9
VIII	**Combinational & Sequential Circuits** Combinational Circuits: Half Adder, Full Adder, Parallel Adder, Half Subtractor, Full Subtractor. Data Processing Circuits: Multiplexer, Demultiplexer, Decoders & Encoders. Sequential Circuits: RS, JK, T & D Flip-Flops, Shift Register (transfer operation of Flip-Flops), and Asynchronous & Synchronous counters.	10

Suggested Readings

PART A

1. R.L. Boylestad, L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice-Hall of India Pvt. Ltd., 2015, 11e
2. J. Millman, C.C. Halkias, Satyabrata Jit, "Electronic Devices and Circuits", McGraw Hill, 2015, 4e
3. B.G. Streetman, S.K. Banerjee, "Solid State Electronic Devices", Pearson Education India, 2015, 7e
4. J.D. Ryder, "Electronic Fundamentals and Applications", Prentice-Hall of India Private Limited, 1975, 5e
5. S.L. Gupta, V. Kumar, "Hand Book of Electronics", Pragati Prakashan, Meerut, 2016, 43e

PART B

1. D. Leach, A. Malvino, Goutam Saha, "Digital Principles and Applications", McGraw Hill, 2010, 7e
2. William H. Gothmann, "Digital Electronics: An Introduction to Theory and Practice", Prentice-Hall of India Private Limited, 1982, 2e
3. R.P. Jain, "Modern Digital Electronics", McGraw Hill, 2009, 4e

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual 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

Course Prerequisites

As per University Guidelines

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

Faculty of Science

Suggested Continuous Internal Evaluation (CIE) Methods

20 marks for Test / Quiz / Assignment / Seminar
05 marks for Class Interaction

Suggested Equivalent Online Courses

1. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy
4. edX, https://www.edx.org/course/subject/physics
5. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/

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 Examinations, equal weightage should be given to Part A (units I to IV) and Part B (units V to VIII) while framing the questions.**

<table>
<tr><td>Programme/Class: Degree</td><td colspan="2">Year: Third (3rd)</td><td colspan="2">Semester: Sixth (VI)</td></tr>
<tr><td colspan="5">Subject: Physics</td></tr>
<tr><td>Course Code: B010603P</td><td colspan="4">Course Title: Analog & Digital Circuits</td></tr>
<tr><td colspan="5">Course Outcomes (COs)</td></tr>
<tr><td colspan="5">Analog & digital circuits have the most striking impact on the industry wherever the electronics instruments are used to study and determine the electronic properties. Measurement precision and perfection is achieved through Lab Experiments. Online Virtual Lab Experiments give an insight in simulation techniques and provide a basis for modeling.</td></tr>
<tr><td colspan="2">Credits: 2</td><td colspan="3">Core Compulsory (Major)</td></tr>
<tr><td colspan="2">Max. Marks: 100 (University Exam)</td><td colspan="3">Min. Passing Marks: As per University Norms</td></tr>
<tr><td colspan="5">Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-4</td></tr>
<tr><td>Unit</td><td colspan="3">Topics</td><td>No. of Lectures</td></tr>
<tr><td></td><td colspan="3">Lab Experiment List
1. Energy band gap of semiconductor by reverse saturation current method
2. Energy band gap of semiconductor by four probe method
3. Hybrid parameters of transistor
4. Characteristics of FET, MOSFET, SCR, UJT
5. FET Conventional Amplifier
6. FET as VVR and VCA
7. Study of basic gates: AND, OR and NOT
8. Study of NAND gate and its use as a Universal gate
9. Study of NOR gate and its use as a Universal gate
10. Verification of laws and theorems of Boolean algebra using NAND gates
11. Simplification of logic circuits using laws and theorems of Boolean algebra
12. Study of XOR gate, Half adder, Full adder, Half subtractor and Full subtractor using OR gate
13. Construction and study of RS, JK, T, D, clocked RS Flip-Flops using NAND / NOR gates
14. Study of Serial In – Parallel Out and Parallel In – Parallel Out shift register
15. Construction and study of 4-bit Digital-to-Analog (D/A) converter (DAC) using R-2R ladder
Online Virtual Lab Experiment List / Link
Virtual Labs an initiative of MHRD Govt. of India
http://vlabs.iitkgp.ac.in/ssd/#
1. ID-VD characteristics of Junction Field Effect Transistor (JFET)
2. Silicon Controlled Rectifier (SCR) characteristics
3. Unijunction Transistor (UJT) and relaxation oscillator</td><td>60</td></tr>
</table>

Virtual Labs an initiative of MHRD Govt. of India
https://de-iitr.vlabs.ac.in/List%20of%20experiments.html

4. Verification and interpretation of truth table for AND, OR, NOT, NAND, NOR, XOR, XNOR gates
5. Construction of half and full adder using XOR and NAND gates and verification of its operation
6. To study and verify half and full subtractor
7. Realization of logic functions with the help of Universal Gates (NAND, NOR)
8. Construction of a NOR gate latch and verification of its operation
9. Verify the truth table of RS, JK, T and D Flip Flops using NAND and NOR gates
10. Design and Verify the 4-Bit Serial In – Parallel Out Shift Registers
11. Implementation and verification of decoder or demultiplexer and encoder using logic gates
12. Implementation of 4x1 multiplexer and 1x4 demultiplexer using logic gates
13. Design and verify the 4-Bit Synchronous or Asynchronous Counter using JK Flip Flop
14. Verify Binary to Gray and Gray to Binary conversion using NAND gates only
15. Verify the truth table of 1-Bit and 2-Bit comparator using logic gates

Suggested Readings

1. R.L. Boylestad, L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice-Hall of India Pvt. Ltd., 2015, 11e
2. J. Millman, C.C. Halkias, Satyabrata Jit, "Electronic Devices and Circuits", McGraw Hill, 2015, 4e
3. B.G. Streetman, S.K. Banerjee, "Solid State Electronic Devices", Pearson Education India, 2015, 7e
4. J.D. Ryder, "Electronic Fundamentals and Applications", Prentice-Hall of India Private Limited, 1975, 5e
5. S.L. Gupta, V. Kumar, "Hand Book of Electronics", Pragati Prakashan, Meerut, 2016, 43e
6. D. Leach, A. Malvino, Goutam Saha, "Digital Principles and Applications", McGraw Hill, 2010, 7e
7. William H. Gothmann, "Digital Electronics: An Introduction to Theory and Practice", Prentice-Hall of India Private Limited, 1982, 2e
8. R.P. Jain, "Modern Digital Electronics", McGraw Hill, 2009, 4e
9. Lab Experiment Manuals

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual Universities.

Suggestive Digital Platforms / Web Links

1. Virtual Labs an initiative of MHRD Govt. of India, http://vlabs.iitkgp.ac.in/ssd/#
2. Virtual Labs an initiative of MHRD Govt. of India, https://de-iitr.vlabs.ac.in/List%20of%20experiments.html
3. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities.

Course Prerequisites

As per University Guidelines

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

-NA-

Suggested Continuous Internal Evaluation (CIE) Methods

-NA-

Suggested Equivalent Online Courses

Further Suggestions
• The institution may add / modify / change the experiments of the same standard in the subject. • The institution may suggest a minimum number of experiments (say 6) to be performed by each student per semester from the Lab Experiment List. • The institution may suggest a minimum number of experiments (say 3) to be performed by each student per semester from the Online Virtual Lab Experiment List / Link.

V.Singh

FOURTH YEAR
OF
HIGHER EDUCATION

<table>
<tr><th colspan="8">STRUCTURE OF PHYSICS COURSE IN FOURTH YEAR OF HIGHER EDUCATION
FOR
DEGREE IN BACHELOR OF SCIENCE (HONOURS) IN PHYSICS</th></tr>
<tr><th>YEAR</th><th>SEME-STER</th><th>COURSE CODE</th><th colspan="2">PAPER TITLE</th><th>PAPER NATURE</th><th>CREDIT</th><th>PAGE No.</th></tr>
<tr><td rowspan="12">FOURTH YEAR</td><td rowspan="5">VII</td><td>B010701T</td><td colspan="2">Mathematical Methods In Physics</td><td>Theory</td><td>4</td><td>56</td></tr>
<tr><td>B010702T</td><td colspan="2">Classical Physics</td><td>Theory</td><td>4</td><td>57</td></tr>
<tr><td>B010703T</td><td colspan="2">Atomic Physics</td><td>Theory</td><td>4</td><td>58</td></tr>
<tr><td>B010704T</td><td colspan="2">Electrodynamics</td><td>Theory</td><td>4</td><td>59</td></tr>
<tr><td>B010705P</td><td colspan="2">Practical (General Lab-I)</td><td>Practical</td><td>4</td><td>60</td></tr>
<tr><td rowspan="7">VIII</td><td>B010801T</td><td colspan="2">Computational Methods In Physics</td><td>Theory</td><td>4</td><td>61</td></tr>
<tr><td>B010802T</td><td colspan="2">Statistical Physics</td><td>Theory</td><td>4</td><td>62</td></tr>
<tr><td>B010803T</td><td colspan="2">Molecular Physics</td><td>Theory</td><td>4</td><td>63</td></tr>
<tr><td>B010804T</td><td>Plasma Physics</td><td rowspan="3">CHOOSE ANY ONE</td><td>Theory</td><td>4</td><td>64</td></tr>
<tr><td>B010805T</td><td>Non-Conventional Sources Of Energy</td><td>Theory</td><td>4</td><td>65</td></tr>
<tr><td>B010806T</td><td>Physics Of Mesoscopic Systems</td><td>Theory</td><td>4</td><td>66</td></tr>
<tr><td>B010807P</td><td colspan="2">Practical (General Lab-II)</td><td>Practical</td><td>4</td><td>67</td></tr>
</table>

OR

STRUCTURE OF PHYSICS COURSE IN FOURTH YEAR OF HIGHER EDUCATION FOR DEGREE IN BACHELOR OF SCIENCE (HONOURS WITH RESEARCH) IN PHYSICS

YEAR	SEMESTER	COURSE CODE	PAPER TITLE		PAPER NATURE	CREDIT	PAGE No.
FOURTH YEAR	VII	B010701T	Mathematical Methods In Physics	CHOOSE ANY THREE	Theory	4	56
		B010702T	Classical Physics		Theory	4	57
		B010703T	Atomic Physics		Theory	4	58
		B010704T	Electrodynamics		Theory	4	59
		B010705P	Practical (General Lab-I)		Practical	4	60
		B010706R	Dissertation In Physics*		Research	4	68
	VIII	B010801T	Computational Methods In Physics	CHOOSE ANY TWO	Theory	4	61
		B010802T	Statistical Physics		Theory	4	62
		B010803T	Molecular Physics		Theory	4	63
		B010804T	Plasma Physics	CHOOSE ANY ONE	Theory	4	64
		B010805T	Non-Conventional Sources Of Energy		Theory	4	65
		B010806T	Physics Of Mesoscopic Systems		Theory	4	66
		B010807P	Practical (General Lab-II)		Practical	4	67
		B010808R	Dissertation In Physics*		Research	4	68

* Dissertation In Physics of both the Semesters (VII and VIII) will be jointly evaluated at the end of the Semester VIII as per University Guidelines.

OR

STRUCTURE OF PHYSICS COURSE IN FOURTH YEAR OF HIGHER EDUCATION FOR DEGREE IN BACHELOR OF SCIENCE (APPRENTICESHIP / INTERNSHIP EMBEDDED) IN PHYSICS

YEAR	SEMESTER	COURSE CODE	PAPER TITLE	PAPER NATURE	CREDIT	PAGE No.
FOURTH YEAR	VII & VIII	As per the Guidelines laid by the University			40	NA

DETAILED PHYSICS SYLLABUS FOR FOURTH YEAR OF HIGHER EDUCATION

Year: **Fourth (4th)**	Semester: **Seventh (VII)**	Credit: 4
Course Code: **B010701T**	Course Title: **MATHEMATICAL METHODS IN PHYSICS**	

UNIT I: Linear Algebra

(i) Linear vector spaces, subspaces, bases and dimension. Linear product spaces, orthogonality, Cauchy-Schwarz inequality and complete orthonormal sets. Linear independence and orthogonality of vectors & Gram-Schmidt orthogonalisation procedure (proof not included).

(ii) Review the algebra of matrices and special matrices. Representation of linear transformations. Change of basis. Eigenvalues & eigenvectors of matrices and Cayley-Hamilton theorem. Diagonalisation of matrices.

UNIT II: Differential Equations And Special Functions

(i) Solution by series expansion of Hermite, Bessel, Legendre, Associated Legendre, Laguerre and Associated Laguerre differential equations.

(ii) Basic properties (generating functions, recurrence & orthogonality relations and series expansion) of Hermite, Bessel, Legendre, Associated Legendre, Laguerre and Associated Laguerre functions.

(iii) Definition, significance (mathematical and physical), illustrations and useful properties (proof included) of Dirac delta function in one and three dimensions.

(iv) Boundary conditions (Dirichlet and Neumann) and boundary value problems. Definition and useful properties (proof not included) of Green's functions for one and three dimensional cases.

UNIT III: Integral Transforms

(i) Laplace Transform: Introduction and properties (linearity, shifting and change of scale). Laplace transform of derivatives and integrals of a function. Differentiation and integration of Laplace transform. Inverse Laplace transforms.

(ii) Fourier Transform: Introduction and properties (linearity, shifting, change of scale and modulation). Inverse Fourier transforms. Fourier sine & cosine transforms. Fourier integral and Fourier sine & cosine integrals.

UNIT IV: Complex Analysis

(i) Functions of a complex variable and analytic (holomorphic) functions. Cauchy-Riemann conditions.

(ii) Integration in the complex plane, Cauchy's integral theorem and Cauchy's integral formula. Morera's and Liouville's theorem.

(iii) Taylor, Maclaurin and Laurent series.

(iv) Ordinary, singular and isolated singular points. Classification of isolated singular points. Definition and evaluation of residues. Cauchy's residue theorem and Jordan's lemma. Application of Cauchy's residue theorem in evaluation of definite integrals.

(v) Introduction (with examples) of branch point, branch cut and Riemann sheets.

SUGGESTED READINGS

1. G. Arfken: Mathematical Methods for Physicists
2. J. Mathews and R.L. Walker: Mathematical Methods of Physics
3. 4. G.F. Simmons: Differential Equations with Applications and Historical Notes
4. W.W. Bell: Special Functions for Scientists and Engineers
5. 6. R.V. Churchill and J.W. Brown: Complex Variables and Applications
6. M.R. Spiegel: Theory and Problems of Complex Variables

Year: **Fourth (4th)**	Semester: **Seventh (VII)**	Credit: **4**
Course Code: **B010702T**	Course Title: **CLASSICAL PHYSICS**	

UNIT I: Variational Principle And Lagrange's Equations

(i) Variational principle (only statement), Euler's differential equation and simple problems based on geodesics & chrones.

(ii) Review of generalised coordinates and d'Alembert's principle. Derivation of Lagrange's equations from d'Alembert's principle (differential method). Concept of generalised potential and Raleigh dissipation function. Gauge function for Lagrangian.

(iii) Definition of action and Hamilton's variational principle. Derivation of Lagrange's equations from Hamilton's variational principle (integral method).

(iv) Symmetry, invariance and Noether's theorem (only statement).

UNIT II: Legendre's Transformation And Hamilton's Equations

(i) Legendre's transformation (proof included).

(ii) Review of Hamiltonian and its physical significance. Derivation of Hamilton's equations from Legendre's transformation (differential method).

(iii) Modified Hamilton's variational principle. Derivation of Hamilton's equations from modified Hamilton's variational principle (integral method).

(iv) Small delta (δ) and capital delta (Δ) variations. Definition of Maupertuis action (abbreviated action) and Maupertuis principle of least action.

UNIT III: Canonical Transformations

(i) Definition and generator formalism of Canonical Transformation (CT). Principal forms of the generating function (proof included), conditions for canonicality (examples included) and properties of CTs.

(ii) Definition and principal identities (proof included) of Poisson Bracket (PB). Elementary (fundamental) PBs. Invariance of PB under CTs. PB formulation of mechanics, Hamilton's equations in PB formulation and Poisson's theorem.

(iii) Definition and principal identities (proof included) of Lagrange Bracket (LB). Invariance of LB under CTs. Relation between PB and LB.

UNIT IV: Hamilton-Jacobi Theory And Small Oscillations

(i) Hamilton-Jacobi theory, Hamilton's Principal function (S) and Hamilton's Characteristic function (W).

(ii) Action-angle variables.

(iii) Theory of small oscillations using generalised coordinates. Normal modes, normal coordinates and normal frequencies. Symmetric and antisymmetric modes.

SUGGESTED READINGS

1. H. Goldstein: Classical Mechanics
2. N.C. Rana and P.J. Joag: Classical Mechanics
3. D. Strauch: Classical Mechanics-An Introduction

Year: **Fourth (4th)**	Semester: **Seventh (VII)**	Credit: **4**
Course Code: **B010703T**	Course Title: **ATOMIC PHYSICS**	

UNIT I: Quantum Background

(i) Introduction to Spectroscopy (definition & scope), EM spectrum and energy units. Interaction of EM radiation with matter (qualitative discussion). Basic principles of spectroscopy (absorption, emission, scattering)

(ii) Review of Bohr's model for single valence electron systems and quantum mechanical treatment of Hydrogen atom. Concept of spin (intrinsic-spin) of electron. Pauli's exclusion principle & periodic table. Eigen values of orbital, spin & total angular momentum operators (no derivation). Origin & significance of various quantum numbers for single valence electron systems.

(iii) Orbital, spin & total magnetic dipole moments of electron and Lande's g factor. Larmor (theorem) & Thomas (relativistic correction) precessions.

UNIT II: Spectra Of One Valance Electron Systems

(i) Spectroscopic Description of Electronic States: Spectroscopic terms & representation of spectra.

(ii) Theory of Fine Structure: Spin-orbit interaction energy, corresponding term shift & doublet separation. Relativistic correction energy and corresponding term shift. Energy order of fine structure levels, selection rules, allowed transitions (doublets & compound doublets) & intensity rules (qualitative & quantitative). Fine structure of Sodium D line. Fine structure of Hydrogen H-alpha line & Lamb shift.

(iii) Theory of Hyperfine Structure: Isotopic effect. Concept of nuclear spin and nuclear spin & hyperfine splitting quantum numbers. Nuclear spin & electron orbit and nuclear spin & electron spin interaction energies and corresponding term shifts. Energy order of hyperfine structure levels & selection rules. Hyperfine structure of Sodium D2 line.

(iv) Spectra of Alkali Elements: Different series, Rydberg-Schuster law, Runge's law & Ritz combination principle. Term value & quantum defect.

UNIT III: Spectra Of Two Valance Electron Systems

(i) Theory of non-penetrating & penetrating orbits. Theory of various quantum numbers for two valence electron systems & coupling schemes.

(ii) LS (Russell-Saunders) Coupling: Spectroscopic terms for non-equivalent & equivalent (Breit's scheme) electrons. Spin-spin, orbit-orbit & spin-orbit interaction energies. Energy order of fine structure levels, Lande's interval rule, Hund's rule & selection rules.

(iii) jj Coupling: Spectroscopic terms for non-equivalent & equivalent electrons. Spin-spin, orbit-orbit & spin-orbit interaction energies. Energy order of fine structure levels & selection rules.

(iv) Spectra of Alkaline Earth Elements: Singlet & triplet structure of spectra. Different series (example of Calcium).

UNIT IV: Effect Of Magnetic And Electric Fields On Spectra Of One Valance Electron Systems

(i) Zeeman Effect: Introduction (normal & anomalous Zeeman effects). Magnetic interaction energy & corresponding term shift. Selection rules, intensity rules & polarisation rules. Anomalous Zeeman effect of fine structure of Sodium D line.

(ii) Paschen-Back Effect: Introduction. Magnetic interaction energy & corresponding term shift. Selection rules.

(iii) Stark Effect: Qualitative discussion.

SUGGESTED READINGS

1. H.E. White: Introduction to Atomic Spectra
2. B.H. Bransden and C.J. Joachain: Physics of Atoms and Molecules

Year: **Fourth (4th)**	Semester: **Seventh (VII)**	Credit: 4
Course Code: **B010704T**	Course Title: **ELECTRODYNAMICS**	

UNIT I: Fields And Potentials

(i) Conservation of charge (continuity equation), energy (Poynting's theorem) and linear momentum (Newton's third axiom and Maxwell's stress tensor). Boundary conditions for electromagnetic fields.

(ii) Electric polarization of a dielectric and polarizability. Expressions for atomic, deformation (Clausius-Mossotti relation) & orientation (Langevin-Debye theory) polarizabilities, Langevin-Debye equation and Debye equation.

(iii) Multipole expansion of electric potential in terms of Ledendre polynomials (monopole, dipole and quadrupole moments). Dipole-dipole interaction.

(iv) Laplace equation, boundary conditions and uniqueness theorems. Solution of Laplace equation in spherical coordinates (examples of uniformly charged ring & dielectric sphere in uniform electric field).

UNIT II: Gauge Transformation

(i) Review of mathematical transition of electromagnetic forces to fields to potentials. Maxwell's equations in terms of electromagnetic potentials.

(ii) Non-uniqueness of electromagnetic potentials and concept of Gauge. Gauge transformation and invariance of Maxwell's equations under gauge transformation. Maxwell's equations in Coulomb and Lorentz gauge.

(iii) Solution of Maxwell's equations in Lorentz gauge by Green's function (retarded & advanced potentials).

(iv) Electromagnetic potentials (Lienard-Wiechert potentials) and fields due to a moving point charge.

UNIT III: Electromagnetic Radiation

(i) Concept of radiation & power radiated by an accelerated point charge (Larmor's & Lienard's formula).

(ii) Angular distribution of power radiated by an accelerated point charge. Special case of linear acceleration (Bremsstrahlung radiation) and circular acceleration (synchrotron radiation).

(iii) Introduction to radiation reaction (damping). Concept of self-force (only qualitative) and Abraham-Lorentz formula. Abraham-Lorentz equation of motion and its implications.

UNIT IV: Relativistic Electrodynamics

(i) Review of Lorentz Transformation (LT) in Minkowski space and 4-vectors. Lorentz invariants (4D scalar product, 4D volume, d' Alembertian and electric charge).

(ii) Current density 4-vector. LT of current & charge densities. Equation of continuity in terms of current density 4-vector.

(iii) Potential 4-vector. LT of electromagnetic potentials. Lorentz condition in terms of potential 4-vector and its invariance under LT.

(iv) Electromagnetic & dual electromagnetic field tensors. LT of electromagnetic fields. Maxwell's equations in terms of electromagnetic field tensor and their invariance under LT.

SUGGESTED READINGS

1. D.J. Griffiths: Introduction to Electrodynamics
2. J.D. Jackson: Classical Electrodynamics

Year: **Fourth (4th)**	Semester: **Seventh (VII)**	Credit: **4**
Course Code: **B010705P**	Course Title: **PRACTICAL (GENERAL LAB-I)**	

The institution may add / modify the experiments of the same standard, and in addition, can also propose the online Virtual Lab experiments.

1. Y of glass plate by Cornu's method
2. Viscosity of fluid by viscometer method
3. Viscosity of liquid by Mayer's oscillating disc method
4. Velocity of ultrasonic waves in a liquid
5. Study of rotatory dispersion of quartz
6. Michelson's interferometer
7. Fabry Perot etalon
8. Edser-Butler
9. Rayleigh Refractometer
10. Jamin's refractometer
11. Babinet Compensator
12. Fresnel's biprism
13. Grating (Rydberg constant, wavelength of Laser)
14. Polarization
15. Verification of Hartmann's formula
16. Verification of Fresnel's law of reflection
17. Spectra calibration by constant deviation spectrometer
18. Study of Zeeman effect
19. Virtual Experiments, related to above experiments, from the Online Virtual Labs of Ministry of Education, Government of India

Year: **Fourth (4th)**	Semester: **Eighth (VIII)**	Credit: **4**
Course Code: **B010801T**	Course Title: **COMPUTATIONAL METHODS IN PHYSICS**	

UNIT I: Solutions Of Numerical, Algebraic And Transcendental Equations

(i) Introduction; Bisection method; Methods of successive approximation; Method of false position; Newton's iteration method, Geometrical interpretation & convergence; Newton-Raphson method, rate of convergence of Newton-Raphson method.

(ii) Interpolation: Introduction, errors in polynomial interpolation, finite differences (forward, backward & central) and Newton's formula for interpolation.

UNIT II: Solutions Of Simultaneous Linear Equations

(i) Introduction and review of matrix operations.

(ii) Direct Methods: Matrix inversion method, Gauss elimination method and Gauss-Jordan method.

(iii) Iterative Methods: Jacobi method of iteration and Gauss-Seidel iteration method.

(iv) Eigen value problems.

UNIT III: Numerical Differentiation And Integration

(i) Numerical Differentiation: Introduction; Derivatives using Newton's forward & backward difference formula; Derivatives using Stirling's formula.

(ii) Numerical Integration: Introduction; Trapezoidal rule; Simpson's 1/3 rule; Newton-Cotes integration formula; Euler-Maclaurin formula.

UNIT IV: Numerical Solutions Of Differential Equations

(i) Ordinary Differential Equations: Introduction; Power series solution method; Euler's method; Runge-Kutta methods; Predictor – corrector method.

(ii) Partial Differential Equations: Introduction; Classification of partial differential equations (parabolic, elliptical, hyperbolic); Finite difference approximations to derivatives; Laplace equation & its solution by Jacobi method & Gauss-Seidel method.

SUGGESTED READINGS

1. S.S. Sastry: Introductory Methods of Numerical Analysis
2. R.L. Burden and J.D. Faires: Numerical Analysis
3. E. Isaacson and H.B. Keller: Analysis of Numerical Methods
4. W. Cheney and D. Kincaid: Numerical Methods and Computing

Year: **Fourth (4th)**	Semester: **Eighth (VIII)**	Credit: **4**
Course Code: **B010802T**	Course Title: **STATISTICAL PHYSICS**	

UNIT I: Elements Of Ensemble Theory

(i) Review of the elements of ensemble theory (time average, ensemble average & Liouville's theorem).

(ii) Entropy of an ideal gas, Gibbs paradox and Sackur-Terode equation.

(iii) Theory of partition function (including physical significance) and classical limit of the partition function. Expression of partition function in different ensembles and it's relation with various thermodynamical potentials.

UNIT II: Phase Transition

(i) Cooperative phenomena and phase transition. Classification (Ehrenfest & modern) and characteristic properties (phase coexistence; critical point; symmetry; order parameters; critical exponents, scaling relations & universality) of phase transition.

(ii) Gas-Liquid Transitions: Condensation of van der Waals gas.

(iii) Ferromagnetic-Antiferromagnetic Transitions: Ising Model, Bragg-Williams approximation (mean field theory) & Bethe-Peierls approximation. One dimensional Ising model. Landau's phenomenological theory.

(iv) Theory of Bose-Einstein condensation and properties of Bose-Einstein condensate.

UNIT III: Fluctuations

(i) Introduction and derivation of equilibrium thermodynamic fluctuations in temperature, volume, entropy, pressure, energy & concentration.

(ii) Quantitative discussion of the Langevin theory of the Brownian motion.

(iii) Derivation of the Fokker-Planck equation and its solution for negligible mass ensemble of Brownian particles.

(iv) Spectral density, correlation function and Wiener-Khintchine theorem (no derivation) & its application in deriving Nyquist theorem.

UNIT IV: Nonequilibrium Statistical Mechanics

(i) Introduction and phenomenological laws (examples of heat, mass, momentum & charge transfer).

(ii) Linear phenomenological relations and primary & Onsager's phenomenological coefficients.

(iii) Onsager's reciprocal relations, derivation and application for charge & entropy and charge & heat transport in a homogeneous conductor.

(iv) Quantitative discussion of Prigogine's principle of minimum entropy production.

SUGGESTED READINGS

1. R.K. Pathria and P.D. Beale: Statistical Mechanics
2. C. Kittle: Elementary Statistical Physics
3. K. Huang: Introduction to Statistical Physics
4. F. Reif: Statistical Physics

Year: **Fourth (4th)**	Semester: **Eighth (VIII)**	Credit: 4
Course Code: **B010803T**	Course Title: **MOLECULAR PHYSICS**	

UNIT I: Microwave Spectroscopy

(i) Fundamentals of Molecular Spectroscopy & Microwave Spectroscopy. Characterization of EM radiation and quantization of energy. Representation of spectra. Concept of the width and intensity of spectral transitions.

(ii) Born-Oppenheimer approximation, various molecular energy states & nature of associated spectra.

(iii) Principal axes & classification of molecules on the basis of moment of inertia about principal axes.

(iv) Pure Rotational Spectroscopy: Salient features. Rotational energy levels of diatomic molecules under rigid rotator & non-rigid rotator models. Rotational quantum numbers & selection rules. Isotope effect. Intensity of spectral lines. Energy level diagram & spectral structure. Applications of rotational spectroscopy. Rotational spectra of polyatomic molecules (linear, rigid symmetric top & non-rigid symmetric top).

UNIT II: Infra-Red (IR) Spectroscopy

(i) Pure Vibrational Spectroscopy: Salient features. Vibrational energy levels of diatomic molecules under harmonic & anharmonic oscillator models. Vibrational quantum numbers & selection rules. Isotope effect. Intensity of spectral lines. Energy level diagram & spectral structure. Applications of vibrational spectroscopy.

(ii) Vibrational-Rotational Spectroscopy of Diatomic Molecules: Salient features. Vibrational-Rotational energy levels of diatomic molecules without & with vibration-rotation interaction. Selection rules & branching notations. Energy level diagram & spectral structure.

(iii) Vibrational-Rotational Spectroscopy of Polyatomic Molecules: Fundamental vibrations & their symmetry for linear & non-linear (acyclic) molecules (examples included). Selection rules for linear molecules.

(iv) Raman Spectroscopy: Salient features. Pure rotational, pure vibrational & vibrational-rotational Raman Spectra for linear molecules. Stokes & anti Stokes Raman lines. Selection rules. Energy level diagram & spectral structure. Complementarity of Raman & IR spectra and rule of mutual exclusion.

UNIT III: Ultra-Violet (UV) And Visible (Vis) Spectroscopy

(i) Electronic-Vibrational Spectroscopy of Diatomic Molecules: Salient features. Electronic-Vibrational energy levels of diatomic molecules. Selection rules. Energy level diagram & spectral structure. Intensity of spectral lines & Franck-Condon Principle (explanation for absorption & emission spectra).

(ii) Dissociation, predissociation & dissociation energy. Determination of dissociation energy (Birge-Sponer method), dissociation limit & product of dissociation.

(iii) Rotational Fine Structure of Electronic-Vibrational Spectroscopy of Diatomic Molecules: Salient features. Electronic-Vibrational-Rotational energy levels of diatomic molecules. Selection rules. Energy level diagram & spectral structure. The Fortrat diagram.

UNIT IV: Spin Resonance Spectroscopy

(i) Salient features. Spin-magnetic field interaction energy & corresponding energy separation. Population of spin energy levels & relaxation time.

(ii) Qualitative discussion of Electron Spin Resonance (E.S.R.) & Nuclear Magnetic Resonance (N.M.R.) and their applications.

SUGGESTED READINGS

1. C.N. Banwell and E. McCash: Fundamentals of Molecular Spectroscopy
2. G. Aruldhes: Molecular Structure and Spectroscopy
3. J.M. Hollas: Molecular Spectroscopy

Year: **Fourth (4th)**	Semester: **Eighth (VIII)**	Credit: 4
Course Code: **B010804T**	Course Title: **PLASMA PHYSICS**	

UNIT I: Motion Of Charged Particles In Electromagnetic Fields

(i) Motion in electric field constant in space & time. Motion in magnetic field constant in space & time (guiding centre, cyclotron velocity, cyclotron frequency, cyclotron radius, magnetic rigidity and magnetic dipole moment). Motion in electromagnetic field constant in space & time (drift velocity & drift acceleration of guiding centre and electric field drift).

(ii) Motion in magnetic field constant in time but slowly varying in space through first order orbit theory (Alfven approximation). Gradient, curvature and combined gradient-curvature drifts. Magnetic dipole moment & magnetic flux. Magnetic mirror, magnetic mirror effect & magnetic bottle (plasma confinement).

(iii) Motion in combined electric field constant in space but varying in time and magnetic field constant in space & time. Polarization drift and adiabatic invariants.

UNIT II: Macroscopic Transport Equations

(i) Phase space, distribution function, homogeneous & inhomogeneous plasma and isotropic & anisotropic plasma. Average values and velocity moments of distribution function. Physical interpretations of first (number density), second (average velocity), third (momentum & pressure dyad) and fourth (total energy & thermal energy triad) velocity moments of distribution function.

(ii) Boltzmann Equation (BE) without & with collision effects. Boltzmann-Vlasov equation. Macroscopic Transport Equations (MTEs) through velocity moments of BE. Derivation & interpretation of first (mass transport), second (momentum transport) & third (energy transport) velocity moments of BE. Solution of MTEs for cold plasma model (Magnetoionic theory) and warm plasma model (Adiabatic approximation).

(iii) Magneto-Hydrodynamic Equations (MHDEs) from average values of MTEs. Simplified MHDEs, magnetic stress and pinch effect.

UNIT III: Basic Plasma Phenomena

(i) Meaning and definition of Plasma. Quasineutral. Collective behavior, Debye shielding, Debye length, Debye sphere, plasma parameter (g) and plasma approximation. Criteria for system to be plasma.

(ii) Plasma oscillations, electron plasma oscillations and electron plasma frequency in cold plasma model.

UNIT IV: Waves In Plasma

(i) Important terms: Phase & group velocity; dispersion relation; Non-dispersive & dispersive media; Normal & anomalous dispersion; Longitudinal & transverse waves; Cut-offs & resonances.

(ii) Magnetohydrodynamic Waves: Velocity of Sound (adiabatic sound velocity), Alfven (Alfven velocity) and Magnetosonic (compressional Alfven waves) waves.

(iii) Electron Waves in Cold Plasma Model: Derivation of Appleton-Hartree equation. Solutions for parallel and perpendicular components of electric field for **k** parallel to $\mathbf{B_0}$ & **k** perpendicular to $\mathbf{B_0}$ [Dispersion relations; Cut-offs & resonances; Right-hand Circularly polarized (RCP), Left-hand Circularly polarized (LCP), Ordinary (O) and extraordinary (X) waves]. CMA diagram.

(iv) Faraday rotation, Faraday angle & uses of Faraday rotation.

SUGGESTED READINGS

1. J.A. Bittencourt: Fundamental of Plasma Physics
2. F.F. Chen: Introduction to Plasma Physics and Controlled Fusion

Year: **Fourth (4th)**	Semester: **Eighth (VIII)**	Credit: **4**
Course Code: **B010805T**	Course Title: **NON-CONVENTIONAL SOURCES OF ENERGY**	

UNIT I: Solar And Wind Energy

(i) Introduction to world energy scenario, Renewable energy resources, Radiation solar geometry, Radiation models.

(ii) Solar Energy: Solar thermal, Optical efficiency, Thermal efficiency. Concentrators, Introduction to solar thermal systems, Solar architecture, Solar still, Air heater, Panel systems.

(iii) Solar Photovoltaic Technology: Fundamentals of solar PV cells & systems. Fabrication & manufacturing process of 1,2,3-generation of PV technologies. Working principle & performance of different photovoltaic modules.

(iv) Wind Energy Technology: Fundamentals of wind energy technology and economics, Resources, Wind energy conversion systems. Cp-λ curve & Betz limits, Wind recourse analysis. OTEC power.

UNIT II: Bio And Nuclear Energy

(i) Biomass: Generation, Characterization. Various methods of biomass utilization of energy generation: gasification, briquette, palatization, syn-gas.

(ii) Biogas: Aerobic and Anaerobic bio conversion processes, Microbial reactions purification, Properties of biogas storage and enrichment, Types of biogas digesters, Combustion characteristics of biogas and its different utilizations. Ethanol and biodiesel production.

(iii) Fusion: Introduction, Basic concepts, Fusion reaction physics, Thermonuclear reaction criterion, Confinement, Scheme, Inertial and Magnetic confinement fusion.

UNIT III: Hydro And Geothermal Energy

(i) Hydro Energy: Basic principle of hydroelectric power generation, Classification of hydropower schemes (pico, micro, mini, small and large hydro projects), Classification of hydro turbine, Turbine theory, Essential components of hydroelectric systems.

(ii) Geothermal Energy: Geothermal regions, Types of geothermal resources, Analysis of geothermal resources, Geothermal energy conversion technologies.

UNIT IV: Fuel Cells And Hydrogen Energy

(i) Introduction and principle of fuel cells, Types of fuel cell: AFC, PEMFC, MCFC, SOFC, Microbial Fuel cell, Fuel cell performance. Polarization curves, Components, Low & high temperature fuel cells, Fuel cell stacks Fuel cell system design and technology.

(ii) Hydrogen as a renewable energy source. Sources of hydrogen, Methods of hydrogen production: Direct electrolysis of water, Thermal decomposition of water. Basic principle of direct energy conversion using fuel cells. Other systems: Tidal, wave and ocean energy.

SUGGESTED READINGS

1. J.A. Duffie and W.A. Beckman: Solar Engineering of Thermal Processes
2. G.N. Tiwari and M.K. Ghosal: Fundamentals of Renewable Energy Sources
3. V.K. Mutha: Hand Book of Bioenergy and Biofuel
4. A. Dahiya: Bioenergy-Biomass to Biofuels
5. H. Wagner and J. Mathur: Introduction to Hydro Energy Systems-Basics, Technology & Operation
6. K.S. Johan and E.F. Richards: Fundamentals of Nuclear Science and Engineering
7. J. Topler and J. Lehmann: Hydrogen and Fuel Cell

Year: **Fourth (4th)**	Semester: **Eighth (VIII)**	Credit: 4
Course Code: **B010806T**	Course Title: **PHYSICS OF MESOSCOPIC SYSTEMS**	

UNIT I: Introduction To Nanoscience

(i) Characteristics scale in mesoscopic systems - nanoparticles, surface to volume ratio, grain boundary volume, surface energy, lattice contraction in nanostructured materials, semiconductor nano particles, blue shift of band gap.

(ii) Magic numbers, theoretical modelling of nanoparticles, carbon nanostructures, organic compounds & polymers, bulk nanostructured materials, self–assembly, nanostructured ferromagnetism, catalysts, optical & vibration spectroscopy, biological materials.

UNIT II: Quantum Confined Systems

(i) Low-dimensional systems, density of states in semiconductor materials, Quantum wells, Quantum wires, Quantum dots, lithographic defined Quantum dots, epitaxially self-assembled Quantum dots, colloidal Quantum dots, weak confinememt regimes, strong confinement limit.

(ii) Quantum wire devices, transport in one-dimensional electron systems (1DES), ideal 1DES, semiconductor 1DEDs, silicon 1DESs, semiconductor Quantum dots as zero dimentional electron systems (0DES).

UNIT III: Mesoscopic Magnetism And Electrical Properties

(i) Magnetism in nanostructures, characteristics of nanomagnetic materials, magnetic properties of single-domain particles, superparamagnetism, coercivity of small particles, measurements of superparamagnetism and blocking temperature, anti ferromagnetic nanoparticles.

(ii) Electrical properties of semiconductor nanocrystals, theory of electron transfer between localized states, photoinduced charge transfer at nanoscale semiconductor interface, electrical conduction in bulk & nanostructured, charge transport in nanocrystal films.

UNIT IV: Nanophotonics

(i) Foundation of nanophotonics, free-space propagation, confinement of photons and electrons, propagation through a classically forbidden zone, localization under a periodic potential, nanoscale optical interactions, near field-optics.

(ii) Photonic crystals, basic concepts, theoretical modeling of photonic crystals, methods of fabrication, photonic crystals and optical communication-introduction.

SUGGESTED READINGS

1. Carles P. Poole Jr. and Frank J. Owens: Introduction to Nanotechnology
2. Michel Kholer: Nanotechnology-Introduction to Nanostructuring Techniques
3. Omar Manasresh: Introduction to Nanomaterials and Devices
4. D. Shi, B. Aktas, L. Pust and F. Mikailov: Nanostructured Magnetic Materials and Their Applications
5. S.V. Gaponenko: Optical Properties of Semiconductor Nanocrystals
6. Paras N. Prasad: Nanophotonics
7. Byung-Gook Park, Sung Woo Hwang and Young June Park: Nanoelectronic Devices

Year: **Fourth (4th)**	Semester: **Eighth (VIII)**	Credit: **4**
Course Code: **B010807P**	Course Title: **PRACTICAL (GENERAL LAB-II)**	

The institution may add / modify the experiments of the same standard, and in addition, can also propose the online Virtual Lab experiments.

1. Hall constant of metal
2. Hall effect in semiconductor
3. LCR at high frequencies
4. High resistance by leakage method
5. Ballistic galvanometer
6. Stefan's constant
7. e/m of electron by Thomson method
8. e/m of electron by Millikan oil drop method
9. e/m of electron by Zeeman effect experiment
10. h by photoelectric cell
11. Electron Spin Resonance (ESR)
12. Four probe method
13. Hysteresis
14. Magnetic susceptibility of liquid using Quinke's method
15. Curie temperature of magnetic materials
16. Dielectric constant and Curie temperature of ferroelectric ceramics
17. Solar cell characteristics
18. Virtual Experiments, related to above experiments, from the Online Virtual Labs of Ministry of Education, Government of India

<table>
<tr><td rowspan="2">Year: Fourth (4th)</td><td>Semester: Seventh (VII)</td><td>Credit: 4</td></tr>
<tr><td>Semester: Eighth (VIII)</td><td>Credit: 4</td></tr>
<tr><td>Course Code: B010706R</td><td colspan="2" rowspan="2">Course Title: DISSERTATION IN PHYSICS</td></tr>
<tr><td>Course Code: B010808R</td></tr>
</table>

The Dissertation In Physics will be based upon the guidelines laid by the University.

V. Singh

FIFTH YEAR
OF
HIGHER EDUCATION

STRUCTURE OF PHYSICS COURSE IN FIFTH YEAR OF HIGHER EDUCATION FOR DEGREE IN MASTER OF SCIENCE (PHYSICS)

YEAR	SEMESTER	COURSE CODE	PAPER TITLE		PAPER NATURE	CREDIT	PAGE No.
FIFTH YEAR	IX	B010901T	Quantum Mechanics		Theory	4	72
		B010902T	Nuclear Physics		Theory	4	73
		SPECIALISATION PAPER: SELECT ANY SET (A / B / C# / D#) # Set C / D can be selected only if Papers B010805T / B010806T respectively have been studied in Semester VIII.					
		B010903T	Advanced Electronics–I	SET A	Theory	4	74
		B010904P	Practical (Advanced Electronics–I)	SET A	Practical	4	75
		B010905T	Condensed Matter Physics–I	SET B	Theory	4	76
		B010906P	Practical (Condensed Matter Physics–I)	SET B	Practical	4	77
		B010907T	Renewable Energy Physics–I	SET C	Theory	4	78
		B010908P	Practical (Renewable Energy Physics–I)	SET C	Practical	4	79
		B010909T	Nanophysics-I	SET D	Theory	4	80
		B010910P	Practical (Nanophysics-I)	SET D	Practical	4	81
		B010911R	PG Dissertation In Physics*		Research	4	92
	X	B011001T	Advanced Quantum Mechanics		Theory	4	82
		B011002T	Particle Physics		Theory	4	83
		SPECIALISATION PAPER: SAME SET AS SELECTED IN SEMESTER IX					
		B011003T	Advanced Electronics–II	SET A	Theory	4	84
		B011004P	Practical (Advanced Electronics–II)	SET A	Practical	4	85
		B011005T	Condensed Matter Physics–II	SET B	Theory	4	86
		B011006P	Practical (Condensed Matter Physics–II)	SET B	Practical	4	87
		B011007T	Renewable Energy Physics–II	SET C	Theory	4	88
		B011008P	Practical (Renewable Energy Physics–II)	SET C	Practical	4	89
		B011009T	Nanophysics-II	SET D	Theory	4	90
		B011010P	Practical (Nanophysics-II)	SET D	Practical	4	91
		B011011R	PG Dissertation In Physics*		Research	4	92

* PG Dissertation In Physics of both the Semesters (IX and X) will be jointly evaluated at the end of the Semester X as per University Guidelines.

V. Singh

DETAILED PHYSICS SYLLABUS
FOR
FIFTH YEAR
OF HIGHER EDUCATION

Year: **Fifth (5^{th})**	Semester: **Ninth (IX)**	Credit: 4
Course Code: **B010901T**	Course Title: **QUANTUM MECHANICS**	

UNIT I: Operator Formalism Of Quantum Mechanics
(i) Vector Space: Review of properties of linear vector space; Hilbert space & related properties; Square-integrable functions; Dirac algebra, bra & ket notations & properties.
(ii) Operators: Operator as an endomorphism on vector space, operator algebra & special operators; Self Adjoint operators & related properties; Eigen values & eigen vectors of an operator; Linear superposition of eigen vectors & degeneracy; Commutators, commutator algebra & commutation relations; General form of uncertainty relation between two operators (proof included).
(iii) Representation In Discrete Bases: Introduction; Matrix representation of kets, bras & operators; Change of bases & unitary transformations; Eigen value problem; Matrix mechanics.
(iv) Representation In Continuous Bases: Introduction; Representation of kets, bras & operators; Position & momentum representation and connecting relations; Momentum operator in position representation & vice versa; Wave mechanics.

UNIT II: Theory Of Angular Momentum
(i) Orbital angular momentum operator in spherical coordinates and commutation relations. Eigen functions and eigen values of orbital angular momentum operators for spherically symmetric potentials. Relation between orbital angular momentum operator and rotation operator.
(ii) Total angular momentum operator, ladder operators, commutation relations, eigen values and explicit form of angular momentum matrices.
(iii) Intrinsic-spin angular momentum operator and commutation relations. Eigen functions (spinors) and eigen values. Pauli spin operators (matrices) and their properties.
(iv) Coupling of two angular momenta, Clebsch-Gordan Coefficients (CGCs), properties of CGCs and evaluation of CGCs for $j_1 = j_2 = ½$ and $j_1 = 1$, $j_2 = ½$.

UNIT III: Approximation Methods - 1
(i) Time Independent Perturbation Theory For Non-Degenerate States: Introduction; first & second order perturbation theory; first & second order correction to eigen energy & eigen function. Applications–Anharmonic linear oscillator; normal Zeeman effect without electron spin; two electron systems (He atom).
(ii) Time Independent Perturbation Theory For Degenerate States: Introduction; first order correction to eigen energy; zeroth order correction to eigen function. Applications--Stark effect in Hydrogen atom.
(iii) Variational Method: Introduction; ground state energy. Applications–one electron systems (H atom); two electron systems (He atom).

UNIT IV: Approximation Methods - 2
(i) Molecular Orbital Theory (MOT): Linear Combination of Atomic Orbitals (LCAO). Application to H_2^+ ion.
(ii) Valence Bond Theory (VBT): Heitler-London theory. Application to H_2 molecule.
(iii) JWKB Approximation: Introduction, conditions for applicability and connection formulae. General expression for scattering problems; transmission & reflection coefficients; application to Gamow's theory of alpha decay. General expression for bound state problems; application to linear harmonic oscillator.

SUGGESTED READINGS
1. L.I. Schiff: Quantum Mechanics
2. N. Zettili: Quantum Mechanics-Concepts and Applications
3. D.J. Griffiths: Introduction to Quantum Mechanics
4. A. Ghatak and S. Lokanathan: Quantum Mechanics-Theory and Applications

Year: Fifth (5^{th})	Semester: Ninth (IX)	Credit: 4
Course Code: B010902T	Course Title: NUCLEAR PHYSICS	

UNIT I: Nuclear Interaction

(i) Review of nuclear interaction and nucleon-nucleon interaction in bound states.

(ii) Nucleon-Nucleon Interaction In Scattering States: Partial wave analysis; Scattering length & effective range theory; Singlet & triplet states; Experimental results for nucleon-nucleon scattering; Scattering by ortho & para Hydrogen molecules.

(iii) Nuclear Force: Properties of nuclear force; Charge independence & concept of isospin; Generalized Pauli principle, spectroscopic notations & mixing of states; Exchange operators; Exchange forces; Meson theory for nuclear force.

UNIT II: Nuclear Models

(i) Liquid Drop Model: Salient features of Liquid Drop model. Bethe-Weizsacker mass formula & its applications. Bohr-Wheeler theory of nuclear fission.

(ii) Shell Model: Experimental evidence for shell effects. Salient features of Shell model. Single particle states (energy levels), spin-orbit interaction, spectroscopic notation, energy level diagram and reproduction of magic numbers. Applications – Ground state angular momentum & parity; Magnetic dipole moment, Schmidt lines; Electric quadrupole moment; Islands of nuclear isomerism.

(iii) Collective Model: Salient features of Collective model. Rotational and Vibrational energy levels.

UNIT III: Nuclear Reactions

(i) Bethe's notation; Conservation laws; Nuclear reaction kinematics (Q-value, Q-equation & its solution).

(ii) Nuclear reaction cross-section & partial wave analysis. Scattering cross-section vs nuclear reaction cross-section. Shadow scattering.

(iii) Compound nucleus theory & experimental evidences. Mechanism of direct reactions with examples of stripping & pick-up (reverse transfer) reactions.

(iv) Reciprocity Theorem (principle of detailed balance); Breit-Wigner one level formula (yield of a nuclear reaction); Scattering matrix (S-matrix), properties of S-matrix & cross-section in terms of S-matrix.

UNIT IV: Nuclear Decay

(i) Beta Decay: Shape of beta spectrum & salient features of beta decay; Fermi theory of beta decay; Fermi-Kurie plot; Decay constant; Sargent's law; Comparative half-life; Allowed & forbidden transitions; Selection rules (Fermi & Gamow-Teller)

(ii) Electron Capture (EC): Theory of EC, radiation emission (X-rays) and electron emission (Auger effect).

(iii) Nuclear De-excitation: (a) Gamma Decay – Salient features of gamma decay, multipole transitions, selection rules for total angular momentum & parity and probability of emission (b) Internal Conversion -- Salient features of internal conversion, total decay constant, conversion coefficient, selection rules and discrete spectrum (c) Internal Pair Creation – Salient features and probability for internal pair creation.

(iv) Nuclear Isomerism: Nuclear isomerism, isomeric transitions and probability of transition.

SUGGESTED READINGS

1. B.L. Cohen: Concepts of Nuclear Physics
2. S.N. Ghoshal: Nuclear Physics
3. M.K. Pal: Theory of Nuclear Structure

Year: **Fifth (5th)**	Semester: **Ninth (IX)**	Credit: **4**
Course Code: **B010903T**	Course Title: **ADVANCED ELECTRONICS-I**	

UNIT I: Operational Amplifiers

(i) Circuit techniques for linear ICs – Direct Coupling, DC biasing, Negative Feedback circuits, Impedance scalars, Inductance simulators, Constant-Current source, DC level shifting, Output stages. D.C. amplifier and drift problems. Compensation techniques. Differential Amplifier – Analysis, Rejection of Common Mode signals, Constant-Current replacement for Re, DC level shifter and complimentary output stage. Transfer characteristics of a Differential Amplifier.

(ii) Operational Amplifiers and their performance characteristics. Offset error voltage and current, Thermal drift, Practical Op-Amp, Frequency compensation and Slew-rate. Op-Amps with Feedback. Analysis of Voltage-Series and Voltage-Shunt Feedback Op-Amps and their applications.

UNIT II: Analog Systems

(i) Adder, Sub-tractor, Differentiator, Integrator, Solution of second order differential equations. Time Scaling, Amplitude Scaling. Generation of functions of time and dependent variable. Estimation of the maximum value. Simulation of time-varying systems.

(ii) Active Filters, Logarithmic Amplifier, Anti-Logarithmic Amplifier, Analog multipliers & divider circuits, Multifunction converter, Phase shifter, RMS converter. Voltage Limiters, Precision Rectifier, Peak Detector, Sample-and-hold circuit, Analog multiplexer.

UNIT III: Signal Generators And Converters

(i) Comparators, Window Comparator, Precision Comparator (IC-311) and their Biomedical application. Effect of Noise on Comparator Circuit. Regenerative Comparator (Schmitt-Trigger), Zero-Crossing Detector with Hysteresis, Voltage-Level Detectors with Hysteresis. Square wave generator, Pulse generator, Triangle wave generator. The 555-timer, 555-timer as a Monostable, Astable Multivibrator and their applications.

(ii) Voltage-to-Frequency Converter, Frequency-to-Voltage Converter, Phase locked loop, Analog-to-Digital Converter, Digital–to–Analog Converter. V/I Converter & I/V Converter. Solar Cell Current-to-Voltage Converter.

UNIT IV: Microprocessor

(i) Basics of Microprocessor, Microprocessor systems with Bus Organization. Microprocessor architecture and its Operations. Semiconductor Memory organization and operations. Internal organization of Memory – Write & Read operations and timing characteristics. Classification and characteristics of Memories – Random Access Memory (RAM), Read Only Memory (ROM), Electrically Erasable PROM (EEPROM).

(ii) Addressing Modes, Interrupts, Parallel & Serial data transfer schemes, Instructions and Data flow, Timer and Timing diagram. Architectural advancement of Microprocessor – Pipelning, Cache Memory, Memory Management, Virtual Memory System. Internal Architecture of 8-bit Microprocessor (8085) and its Functional Pin Diagram.

SUGGESTED READINGS

1. J. Millman and C.C. Halkias: Integrated Electronics-Analog and Digital Circuits and Systems
2. J.G. Graeme, G.E. Tobey and L.P. Huelsman: Operational Amplifiers-Design and Applications
3. G.A. Korn and T.M. Korn: Electronic Analog and Hybrid Computers
4. Robert F. Coughlin and Frederick F. Driscoll: Operational Amplifiers and Integrated Circuits
5. V. Rajaraman: Analog Computation and Simulation
6. Ramakant A. Gayakwad: Op-Amp and Linear Integrated Circuits
7. U.S. Shah: Introduction to Microprocessor

Year: **Fifth (5th)**	Semester: **Ninth (IX)**	Credit: **4**
Course Code: **B010904P**	Course Title: **PRACTICAL (ADVANCED ELECTRONICS-I)**	

The institution may add / modify the experiments of the same standard, and in addition, can also propose the online Virtual Lab experiments.

1. To determine the CMR of differential amplifier (Op-Amp)
2. To study the working of Op-Amp as an inverting and non- inverting amplifier
3. To study the working of Op-Amp as an adder and subtractor
4. To study frequency response of an Op-Amp (a) for close loop (b) for open loop
5. To solve simultaneous equations using Op-Amp
6. To study the low-pass and high-pass active filters using Op-Amp
7. To study the working of an Op-Amp as integrator and differentiator
8. To construct and study Wien bridge oscillator using Op-Amp
9. To study the operation of astable and monostable multivibrator using IC 555 timer
10. Simulation of radioactive decay and harmonic oscillator using Op-Amp
11. To study different shift register configurations
12. To design a digital to analogue converter using Op-Amp
13. To study various applications of decoder and encoder
14. To illustrate the operation of shift register
15. To demonstrate a basic multiplexer / demultiplexer system
16. Virtual Experiments, related to above experiments, from the Online Virtual Labs of Ministry of Education, Government of India

Year: **Fifth (5th)**	Semester: **Ninth (IX)**	Credit: **4**
Course Code: **B010905T**	Course Title: **CONDENSED MATTER PHYSICS-I**	

UNIT I: Crystallography
Crystalline Solid, unit cells and direct lattice, two or three dimensional Bravais lattice, closed packed structure, Interaction of X-ray with matter, Elastic Scattering from a perfect lattice, the reciprocal space and its applications, Powder and rotating crystal method, crystal structure factor. Point defects, line defects and planer (stacking) faults. The role of dislocation in Plastic deformation and crystal growth. Symmetry elements of crystals, concept of point groups, influence of symmetry on physical properties, space groups.

UNIT II: Thermal And Optical Properties Of Solids
Inter atomic force and lattice dynamics of simple metals, Ionic and covalent crystals, optical phonons and dielectric constant, inelastic neutron scattering, Mossbauer effect, Deby-Waller factor, Anharmonicity, Thermal expansion and thermal conductivity, interaction of electrons and phonons with photons, direct and indirect transitions, absorption in insulators, Polaritons, one phonon absorption, optical properties of metal, skin effect, Interaction of electrons with acoustic and optical phonons, polarons.

UNIT-III: Electronic And Magnetic Properties Of Solids
Drude model, Electrons in periodic lattice, Bloch theory, band theory, classifications of solids, Effective mass, Tight bonding approximation, Cellular and pseudo potential methods, Fermi Surface. Dia and para magnetism, Weiss theory of ferromagnetism, spin waves and magnetic Curie Weiss law for susceptibility, Fermi and anti-ferromagnetic order domain and Bloch wall energy.

UNIT IV: Superconductivity
Superconductivity, manifestation of energy gap, critical temperature and magnetic field, persistent current, Meissner effect, Cooper pairing due to phonons, BCS theory of superconductivity, Ginzburg-Landau theory, DC and AC Josephson effect, Vortices in type II superconductors, high temperature superconductors. De Hass Van Alfen effect, cyclotron resonance, magnetoresistance, Quantum Hall effect.

SUGGESTED READINGS
1. C. Kittel: Introduction to Solid State Physics
2. A.J. Dekker: Solid State Physics
3. Neil Ashcroft and N. David Mermin: Solid State Physics
4. R.K. Puri and V.K. Babbar: Solid State Physics
5. S.O. Pillai: Solid State Physics

Year: Fifth (5^{th})	Semester: **Ninth (IX)**	Credit: 4
Course Code: **B010906P**	Course Title: **PRACTICAL (CONDENSED MATTER PHYSICS-I)**	

The institution may add / modify the experiments of the same standard, and in addition, can also propose the online Virtual Lab experiments.

1. Measurement of lattice parameters and indexing of powder photographs
2. Interpretation of transmission Laue photographs
3. Determination of orientation of a crystal by back reflection Laue method
4. Modulus of rigidity and internal friction in metals as a function of temperature
5. Dielectric constant of $BaTiO_3$
6. Conductivity of Germanium
7. Four probe method
8. Hall effect
9. Virtual Experiments, related to above experiments, from the Online Virtual Labs of Ministry of Education, Government of India

Year: **Fifth (5th)**	Semester: **Ninth (IX)**	Credit: **4**
Course Code: **B010907T**	Course Title: **RENEWABLE ENERGY PHYSICS-I**	

UNIT I: Solar Thermal Flat Plate Collector

(i) Basics for solar thermal systems: Different design and components; Radiation transmission and absorption through glazing; Selective surfaces: Ideal coating Characteristics, Anti reflecting coating.

(ii) Flat plate collector: theory and basic design aspects; Thermal analysis and effective heat loss; Performance analysis methods; Thermal analysis and effective energy loss of evacuated tube collector; Application of solar flat plate water heater & air heater for industrial process heat. Flat plate solar dryer: Issues and challenges.

UNIT II: Solar Thermal Concentrating Collector

(i) Classification of concentrating collector; concentrating collector configurations; concentration ratio: optical, geometrical; Thermal performance of concentrating collector; Optical And thermal performance of different concentrating collector designs; Parabolic trough concentrators; Compound parabolic concentrator; Concentrators with point focus.

(ii) Solar thermal power plant: Central receiver systems; Heliostats; Comparison of various designs: Parabolic trough systems, Rankine cycle, Parabolic Dish-Stirling system, Combined cycle.

UNIT III: Energy Storage

(i) Energy availability: Demand and storage, Need for energy storage, Different types of energy Storage; Mechanical, Chemical, electrical Electrochemical, Biological, Magnetic Electromagnetic, Thermal; Hydrogen as energy carrier and storage. Basic principle of direct energy conversion using fuel cells. Comparison of energy storage technologies.

(ii) Application of energy storage: Food preservation, Waste heat recovery, Solar energy storage: Greenhouse heating; Drying and heating for process industries.

UNIT IV: Energy Storage Systems

(i) Thermal Energy Storage: Principles and applications, Sensible and Latent heat, Phase change materials, Energy and exergy analysis of thermal energy storage.

(ii) Mechanical Energy Storage: Flywheel And compressed air storage; Pumped hydro storage; Hydrogen energy storage, Capacitor and super capacitor; Principles, performance and applications.

(iii) Electrochemical Energy storage: Battery- fundamentals and technologies, characteristics and performance comparison: Lead-acid, Nickel-Metal hydride, Lithium Ion; Battery system model, emerging trends in batteries.

SUGGESTED READINGS

1. H.P. Garg and S. Prakash: Solar Energy-Fundamental and Application
2. G.N. Tiwari: Solar Energy-Fundamentals, Design, Modeling and Applications
3. J.K. Nayak and S.P. Sukhatme: Solar Energy-Principles of Thermal Collection and Storage
4. I. Dincer and M.A. Rosen: Thermal Energy Storage-Systems and Applications
5. R. O'Hayre, Suk-Won Cha, W. Colella and Fritz B. Prinz: Fuel Cell Fundamentals
6. R. Narayan and B. Viswanathan: Chemical and Electrochemical Energy Systems

Year: **Fifth (5th)**	Semester: **Ninth (IX)**	Credit: **4**
Course Code: **B010908P**	Course Title: **PRACTICAL (RENEWABLE ENERGY PHYSICS-I)**	

The institution may add / modify the experiments of the same standard, and in addition, can also propose the online Virtual Lab experiments.

1. Study of I-V and P-V characteristics of series and parallel combination of PV module
2. Determination of performance (UL, FR, η) of the parabolic trough collector with fixed parameters with (i) water and (ii) Oil as working fluid
3. Evaluation of UL, FR, η in thermosphonic mode of flow with fixed input parameters
4. To find the thermal efficiency of natural draft cook-stove as per BIS standards
5. Study of kinetic energy of photo electrons as a function of frequency of incident radiation
6. Solar energy measurement using a Pyrheliometer
7. Effect of temperature on solar energy production
8. Study of solar charge controllers
9. Virtual Experiments, related to above experiments, from the Online Virtual Labs of Ministry of Education, Government of India

Year: **Fifth (5^{th})**	Semester: **Ninth (IX)**	Credit: **4**
Course Code: **B010909T**	Course Title: **NANOPHYSICS-I**	

UNIT I: Physical Methods Of Synthesis

Thermal Evaporation-Phase collision and nucleation (condensation of Inert gas), Microwave/Gamma irradiation synthesis of NPs, Argon Ion Sputtering- DC diode, RF radio and Magnetron sputtering, Arc discharge, RF-plasma, Plasma arc technique, Laser pyrolysis, Pulsed Laser Ablation (PLA) synthesis, Mechanical (Ball Milling) method, Lithography techniques, Molecular beam epitaxy, Chemical vapour deposition method and other variants, electrodeposition.

UNIT II: Chemical Methods Of Synthesis

Metal nanocrystals by reduction, Solvothermal synthesis, Photochemical synthesis, nanocrystals of semiconductors and other materials by arrested precipitation, Thermolysis and Sonochemical routes, Liquid-liquid interface, Hybrid methods, Solvated metal atom dispersion, post-synthesis size-selective processing. Sol gel, micelles and microemulsion, Cluster compound.

UNIT-III: Scattering And Imaging Techniques Of Characterizations

X-ray Diffraction, Dynamic light scattering, Light Microscopy, Scanning Electron Microscopy techniques-secondary electron imaging, backscattered electron imaging, Electron backscattered diffraction, high resolution imaging. Scanning Probe Microscopy Techniques-Atomic Force, Piezeo Force and Scanning Tunneling Microscopy.

UNIT IV: Spectroscopic Techniques Of Characterizations

UV-Visible-Infrared and Fourier-Transform Infrared Spectroscopy. Raman X-ray Photoelectron Spectroscopy, Auger Spectroscopy, Energy Dispersive and Wavelength Dispersive X-ray Spectroscopy, Electron Energy Loss Spectroscopy, Scanning Tunneling Spectroscopy, Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC)-Thermo-Gravimetric Analysis (TGA), Photoluminescence, Fluorescence, Phosphorescence, Electroluminescence, Photoconductivity. Basic idea of Electric and Magnetic measurement techniques.

SUGGESTED READINGS

1. Guozhong Cao and Ying Wang: Nanostructures & Nanomaterials-Synthesis, Properties and Applications
2. C.N.R. Rao, A. Muller, A.K. Cheetham: The Chemistry of Nanomaterials: Synthesis, Properties and Applications
3. Yury Gogotsi: Nanomaterials Handbook
4. S. Zhang, Lin Li and A. Kumar: Material Characterization Techniques
5. Y. Leng: Material Characterization-Introduction to Microscopic and Spectroscopic Methods
6. D.B. William and C.B. Carter: Transmission Electron Microscopy

Year: **Fifth (5th)**	Semester: **Ninth (IX)**	Credit: 4
Course Code: **B010910P**	Course Title: **PRACTICAL (NANOPHYSICS-I)**	

The institution may add / modify the experiments of the same standard, and in addition, can also propose the online Virtual Lab experiments.

1. Growth of nanoparticles by chemical routes
2. Growth of nanophase by sputtering
3. Growth of quantum dots by thermal evaporation
4. Growth of nanoparticles by mechanical milling / attrition
5. Growth of nanoparticles by nanopores templates method
6. Study of chemical kinetics using UV spectroscopy
7. Structure characterization of nanomaterials by determination of gain size and its distribution
8. Surface morphological characterization of nanomaterials by AFM
9. Virtual Experiments, related to above experiments, from the Online Virtual Labs of Ministry of Education, Government of India

Year: **Fifth (5th)**	Semester: **Tenth (X)**	Credit: **4**
Course Code: **B011001T**	Course Title: **ADVANCED QUANTUM MECHANICS**	

UNIT I: Quantum Theory Of Scattering

(i) Introduction: Laboratory & centre of mass frames; differential & total scattering cross-section; formal theory of quantum scattering; scattering amplitude.

(ii) Born Approximation: Solution of Schrodinger equation by Green's function (integral form of Schrodinger equation) and scattering amplitude. Born approximation, condition for validity, scattering amplitude and differential scattering cross-section. Scattering by screened Coulomb potential (Rutherford's formula) and attractive square well potential.

(iii) Partial Wave Analysis: Partial wave analysis, phase shifts, scattering amplitude, total scattering cross-section and optical theorem. Evaluation of phase shift. Scattering by a hard sphere and attractive square well potential.

UNIT II: Quantum Theory Of Radiation

(i) Time Dependent Perturbation Theory: Introduction; various orders of perturbation; first order transition probability for constant perturbation; Fermi's Golden rule; first order harmonic perturbation.

(ii) Semi-Classical Theory of Radiation: Theory of induced emission and resonance absorption. Electric dipole approximation and first order transition rates for induced emission and resonance absorption.

(iii) Einstein Coefficients: Einstein coefficients and transition rate for spontaneous emission.

UNIT III: Relativistic Quantum Mechanics

(i) Klein-Gordon Equation (KGE): Introduction, relativistic time dependent Schrodinger equation, equation of continuity and KGE in electromagnetic field.

(ii) Dirac Equation (DE): Background, linearization of Hamiltonian by Dirac, Dirac matrices and DE. Gamma matricies & their properties, covariant form of DE and invariance of DE under Lorentz transformation. Equation of continuity.

(iii) Applications of DE: Solution of DE for a free particle (plane wave solutions), DE in electromagnetic field (magnetic moment of electron), DE in central field (intrinsic-spin of electron and spin-orbit coupling energy), solution of DE for Hydrogen atom (energy levels) and negative energy states (Dirac's Hole theory).

UNIT IV: Some Selected Topics

(i) Identical Particles: Meaning of identity and consequences. Particle exchange operator, symmetric & antisymmetric wavefunctions. Exchange degeneracy. Commutator of Hamiltonian & particle exchange operator. Symmetrization of wave functions, Slater determinant and Pauli's exclusion principle. Scattering of identical particles (particles with intrinsic-spin included).

(ii) Harmonic Oscillator: Solution through Dirac's algebraic method, creation, annihilation & number operators, coherent states and time evolution of coherent state.

SUGGESTED READINGS

1. L.I. Schiff: Quantum Mechanics
2. N. Zettili: Quantum Mechanics-Concepts and Applications
3. D.J. Griffiths: Introduction to Quantum Mechanics
4. A. Ghatak and S. Lokanathan: Quantum Mechanics-Theory and Applications

Year: **Fifth (5th)**	Semester: **Tenth (X)**	Credit: **4**
Course Code: **B011002T**	Course Title: **PARTICLE PHYSICS**	

UNIT I: Lie Groups And Lie Algebra

(i) Lie Groups: Review of group postulates, Finite & infinite dimensional groups, Discrete & continuous groups. Lie groups (definition with illustrative examples).

(ii) Representation Theory: Basic idea, Definition, Faithful & unfaithful representations, Reducible & irreducible representations, Matrix representation (with examples)

(iii) Lie Algebra: Generator formalism, Lie Bracket, Lie Algebra (definition with illustrative examples).

(iv) Specific Lie Groups: Connection between conservation laws, symmetries & Lie groups. General properties of Specific Lie groups – Orthogonal O(n), Special Orthogonal SO(n), Unitary U(n) & Special Unitary SU(n). Structure of SO(2), SO(3), SU(2) & SU(3) Lie groups. Application of Lie groups in Physics.

UNIT II: Fundamental Interactions And Elementary Particles

(i) Fundamental Interactions: Basic features – Exchange interaction & properties of mediating quanta; Range & relative strength.

(ii) Elementary Particles: Introduction. Concept of antiparticles (qualitative). Classification of elementary particles based on intrinsic-spin, mass, interaction & lifetime. Families of Leptons, Mesons (pseudoscalar, vector & tensor), Baryons & Baryon Resonances. Gauge bosons.

(iii) Conservation Laws: Conservation law for mass-energy, linear momentum, angular momentum, electric charge, baryonic charge, leptonic charge, isospin (concept of multiplet), strangeness, charge conjugation, parity (space parity & intrinsic parity), time reversal, CP and CPT (CPT theorem). Gell Mann-Nishijima formula and hypercharge.

UNIT III: Quarks

(i) Classification of hadrons on the basis of SU(3) group algebra; Quark hypothesis; Properties of quarks (flavours, mass, electric charge, intrinsic-spin, parity, various quantum numbers, strong charge or colour).

(ii) Eight Fold Way. Quark model of hadrons – Meson (pseudoscalar, vector & tensor) nonets; Baryon octet; Baryaon decuplet (baryon resonances). Gell Mann-Okubo mass formula & mixing of states.

(iii) Elementary ideas of – Gluons & glue ball; Quark confinement & asymptotic freedom; Quark-Parton model (deep inelastic scattering experiments, valence & virtual quarks and proton momentum).

UNIT IV: Some Selected Topics

(i) Neutrino Physics: Fundamentals of beta decay w.r.t. discovery of neutrino; Some historical experiments related with neutrinos; Helicity & chirality of neutrinos; Neutrino flavours; Neutrino mass & neutrino oscillations; Atmospheric, solar & supernova neutrinos; Solar neutrino problem.

(ii) Unification Theories: Introduction. Elementary ideas of – Electroweak Theory (EWT) (spontaneous symmetry breaking included), Standard Model (SM), Grand Unified Theories (GUTs) (magnetic monopoles & proton decay included), Unified Field Theory (UFT) or Theory of Everything (TOE).

SUGGESTED READINGS

1. Howard Georgi: Lie Algebras in Particle Physics
2. Peter Woit: Quantum Theory, Groups and Representations
3. D.J. Griffiths: Introduction to Elementary Particles
4. D.H. Perkins: Introduction to High Energy Physics
5. F. Halzen and A.D. Martin: Quarks and Leptons-An Introductory Course in Modern Particle Physics

Y.Singh Misra

Year: **Fifth (5th)**	Semester: **Tenth (X)**	Credit: **4**
Course Code: **B011003T**	Course Title: **ADVANCED ELECTRONICS-II**	

UNIT I: Modulation And Demodulation

(i) Need of modulation, Amplitude Modulation (Side Bands, Single Side Band Modulation), Frequency Modulation (Frequency spectrum and Bandwidth of F.M. wave), Phase Modulation, comparison with Frequency Modulated Wave.

(ii) Qualitative approach for Amplitude Demodulation, PLL as Frequency Demodulator, Sampling of Analog Signal, Pulse Modulation (Pulse Amplitude Modulation, Pulse Width Modulation and Pulse Position Modulation), Quantization, Pulse Code Modulation.

(iii) Frequency Division Multiplexing, Time Division Multiplexing.

UNIT II: Microwave Electronics

(i) Microwave frequency, Limitations of conventional tubes in Microwave frequency range, Reflex Klystron (velocity modulation, power output and frequency).

(ii) Gun effect and Gun diode, TE and TM Modes in Rectangular Waveguide, Rectangular Cavity Resonator, Isolator, Directional Coupler and Magic Tee (qualitative consideration).

(iii) Microwave Antenna, Microwave Detector, VSWR and Power measurement.

UNIT III: Satellite And Radar Systems

(i) Satellite orbit, Satellite frequencies, Synchronous satellite, Satellite communication (qualitative approach), Transponders.

(ii) Basic Radar System, Derivation of radar equation, Radar block diagram, Radar frequencies, Pulse Radar, Moving Target Indicator Radar, Radar Display, Radar Antenna.

UNIT IV: Antennas And Television

(i) Antenna System, Short-Electric Doublets, radiation from one Pole and Double Aerials, Antenna parameters, Antenna array, Folded Dipole Antenna application, Yagi Antenna.

(ii) General Principle of Image Transmission, Video Camera Tubes (Iconoscope and Image Orthicon), Scanning (Progressive and Interlaced Scanning), Composite Video Signal, TV Bandwidth and Channels, Monochrome Television Transmitter and Receiver (explanation through Block Diagram), Colour Television (qualitative approach), TV System and TV Standards.

SUGGESTED READINGS

1. J. Millman: Analog and Digital Communication Systems
2. G. Kennedy and B. Davis: Electronic Communication Systems
3. H. Taub, D. Schilling and G. Saha: Principles of Communication Systems
4. Rodger E. Ziemer and Willian H. Tranter: Principals of Communications
5. Siman Haykin and Michael Moher: Introduction to Analogue and Digital Communications
6. Samuel Y. Liao: Microwave Devices and Circuits
7. R.R. Gulati: Monochrome and Colour Television

Year: **Fifth (5^{th})**	Semester: **Tenth (X)**	Credit: **4**
Course Code: **B011004P**	Course Title: **PRACTICAL (ADVANCED ELECTRONICS-II)**	

The institution may add / modify the experiments of the same standard, and in addition, can also propose the online Virtual Lab experiments.

1. To study amplitude modulation and demodulation and to calculate the modulation index
2. To study the process of frequency modulation and demodulation and calculate the depth of modulation by varying modulating voltage
3. To study frequency division multiplexing and de multiplexing techniques
4. To study Pulse Amplitude Modulation (PAM) and the effect of amplitude and frequency variation of modulating signal on the PAM output
5. To study Pulse Width Modulation (PWM) and the effect of amplitude and frequency of modulating signal on PWM output
6. To study Pulse Position Modulation (PPM) and the effect of amplitude and frequency of modulating signal on its output and observe the wave forms
7. To study and understand the operation of Pulse Code Modulation (PCM)
8. To draw V-I characteristics of Gun diode
9. To study mode characteristics of reflex klystron
10. To study Voltage Standing Wave Ratio (VSWR) and reflection coefficient for matched load
11. To verify relation between guide wavelength, free space wavelength and cut off wavelength for rectangular waveguide working on TE10 mode
12. To determine frequency and wavelength in a rectangular waveguide working in TE10 mode
13. To determine isolation and coupling coefficients for E and H Plane waveguide Tee junction
14. Virtual Experiments, related to above experiments, from the Online Virtual Labs of Ministry of Education, Government of India

Year: **Fifth (5^{th})**	Semester: **Tenth (X)**	Credit: **4**
Course Code: **B011005T**	Course Title: **CONDENSED MATTER PHYSICS-II**	

UNIT I: Synthesis And Properties Of Nano Materials

Exotic Solids, structure and symmetric of liquid, Liquid Crystal and amorphous solid, Aperiodic solids and Quasi Crystal, Fibonacci sequence, Penrose lattices and their extension to three dimensional. Special Carbon solids, Fullerenes and tubeless, electronic properties of tubules, Carbon nanotube based electronic devices, Definition and properties of nanostructural Materials, Method and synthesis of nanostructured materials, Quantum Size effect and its applications.

UNIT-II: Disorder, Defects And Colour Centre In Solids

Disorder system in condensed Matter Physics, Point defect, Shallow impurity of state in semiconductor, Localized lattice vibrational states of solids, vacancies, interstitial and colour centres in ionic crystals, Substitutional position and topographical disorder, short- and long-range order, atomic correlation function and structural description of glasses and liquid. Mechanism of plastic deformation in solid, stress and strain field of screw and edge dislocations, Elastic energy of dislocations in fcc, hcp and bcc lattices, partial dislocation and stacking solution in close packed structures.

UNIT III: Electronic And Magnetic Correlation In Materials

Interacting Electron gas, Hartee and Hartee Fock approximations, correlations energy, screening effect, Plasma oscillations, di-electric function of an electron gas in random phase approximation. Electron in Surface states, strongly interacting Fermi system, Elementary introduction to Landau's Quasi particle theory of Fermi liquid, strongly correlated electron gas, metallic surface and surface reconstructions.

UNIT IV: Thin Films And Surface Study In Solids

Films and Surfaces, Study of surface topography by multiple beam interferometry, conditions for accurate determination of step height and film thickness (Fizeau Fringes) electrical conductivity of thin films, difference of behaviour of thin films from Boltzmann transport equation (for diffused scattering), expansion for electrical conductivity of thin film elementary concept of surface crystallography scanning, tunneling and atomic force microscopy.

SUGGESTED READINGS

1. C. Kittel: Introduction to Solid State Physics
2. A.J. Dekker: Solid State Physics
3. Neil Ashcroft and N. David Mermin: Solid State Physics
4. R.K. Puri and V.K. Babbar: Solid State Physics
5. S.O. Pillai: Solid State Physics
6. Charles P. Poole Jr. and Frank J. Owens: Introduction to Nanotechnology

Year: **Fifth (5th)**	Semester: **Tenth (X)**	Credit: **4**
Course Code: **B011006P**	Course Title: **PRACTICAL (CONDENSED MATTER PHYSICS-II)**	

The institution may add / modify the experiments of the same standard, and in addition, can also propose the online Virtual Lab experiments.

1. Modulus of rigidity and internal friction in metals as a function of temperature
2. To measure the cleavage step height of a crystal by multiple Fizeau fringes
3. To determine magneto-resistance of semiconductor material in external magnetic field
4. To study hysteresis in the electrical polarization of a TGS crystal
5. Electron Spin Resonance (ESR)
6. Study of fluorescence materials
7. Study of ferromagnetic materials
8. Susceptibility of paramagnetic material
9. Virtual Experiments, related to above experiments, from the Online Virtual Labs of Ministry of Education, Government of India

Year: **Fifth (5th)**	Semester: **Tenth (X)**	Credit: **4**
Course Code: **B011007T**	Course Title: **RENEWABLE ENERGY PHYSICS-II**	

UNIT I: Solar Photovoltaic Array Analysis

(i) Introduction, Solar cell 10 parameters, Production of Si, Fabrication of solar cells, Design of solar cells, Optimization of process parameters, Measurements of solar cell parameters; Short circuit current, Open circuit voltage, Fill factor, Efficiency.

(ii) Photovoltaic module and array, Theory and construction, Series and parallel combinations, Balance of PV array, Partial shading of solar cell and module, Maximum Power Point Tracker (MPPT), Balance of PV System (BOS), Issues and Challenges of PV system operation and maintenance; Factor effecting the PV system performance.

UNIT II: Fuel Cell Technology And Characterization

(i) Introduction, Thermodynamics and Electrochemistry of Fuel Cell: Application of first and second law to fuel cells, significance of the Gibb's free energy, concept of electrochemical potential and e.m.f., half cell potential and the electrochemical series, Faraday's Law, Nernst equation, Butler-Volmer theory, Thermodynamic efficiency of fuel cell in comparison to Carnot efficiencies, Thermodynamic advantages of electro energy conversion.

(ii) Fuel cell systems and sub-systems, systems and sub-systems integration; Power management, Thermal management, Pinch analysis. Fuel cell characterization: In-situ and Ex-situ; System and component's characterization, Modeling a Fuel cell.

UNIT III: Hydrogen Production

(i) Properties of hydrogen as fuel, General introduction to infrastructure requirement for hydrogen production, Thermal-steam reformation, Thermo-chemical water splitting, Gasification-pyrolysis, Storage, Dispensing and utilization, Hydrogen Storage, Metal hydrides, Chemical hydrides, Carbon nano-tubes; Sea as the source of Deuterium, Methane hydrate, etc.

(ii) Bio-Hydrogen: Production of bio hydrogen; Production of hydrogen by fermentative bacteria, Hydrogen, Methane and other Fuel Energy from Algae: Algae Cultivation, Photo-bioreactors.

UNIT IV: Hydrogen Storage And Utilization

(i) Physical and chemical properties, General storage methods, Compressed storage-composite cylinders, Glass micro sphere storage, Zeolites, Metal hydride storage, Chemical hydride storage, Cryogenic storage, Carbon based materials for hydrogen storage, Over of hydrogen utilization, hydrogen burners, Power plant, Marine applications, hydrogen dual fuel engines.

(ii) Hydrogen as an alternative fuel in IC engines; Suitability of Hydrogen as a fuel, and techno-economic aspects of fuel cell as energy conversion device; Hydrogen fuel for transport.

SUGGESTED READINGS

1. C.S. Solanki: Solar Photovoltaic-Fundamentals, Technologies and Applications
2. A.K. Mukerjee and N. Thakur: Photovoltaic Systems-Analysis and Design
3. R. O'Hayre, Suk-Won Cha, W. Colella and Fritz B. Prinz: Fuel Cell Fundamentals
4. W. Vielstich, A. Lamm and H.A. Gasteiger: Hand Book of Fuel Cells-Fundaentals, Technology, Applications
5. B. Soren and G. Spazzafumo: Hydrogen and Fuel Cells-Emerging Technologies and Applications
6. J. Topler and J. Lehmann: Hydrogen and Fuel Cell

Year: **Fifth (5^{th})**	Semester: **Tenth (X)**	Credit: **4**
Course Code: **B011008P**	Course Title: **PRACTICAL (RENEWABLE ENERGY PHYSICS-II)**	

The institution may add / modify the experiments of the same standard, and in addition, can also propose the online Virtual Lab experiments.

1. Various energy analysis by PVsyst software
2. Determination of performance (UL, FR, η) of the parabolic trough collector with variable parameters with (i) water and (ii) Oil as working fluid
3. Evaluation of UL, FR, η in thermosphonic mode of flow different radiation level
4. To find the thermal efficiency of force draft cook-stove as per BIS standards
5. Study of solar cell color sensitivity
6. Study of solar heating
7. Solar energy measurement by Pyranometer
8. Study of power conditioning units for solar energy
9. Virtual Experiments, related to above experiments, from the Online Virtual Labs of Ministry of Education, Government of India

Year: **Fifth (5^{th})**	Semester: **Tenth (X)**	Credit: **4**
Course Code: **B011009T**	Course Title: **NANOPHYSICS-II**	

UNIT I: Quantum Devices

Charge and spin in single quantum dots, Coulomb blockade, Electrons in mesoscopic structures , Single Electron Transfer devices (SETs), Electron Spin transistor, resonant tunnel dioded, Tunnel Field Effect Transistors (FET), Quantum Interference Transistors (QUITs), Quantum bits (qubits).

UNIT II: Nanoelectonic Devices

Electronic transport in 1, 2 and 3 dimensions, Quantum confinement, energy sub-bands, effective mass, Drude conduction, mean free path in 3D, ballistic condition, phase coherence length, quantized conductance, Buttiker-Landauer formula, Electron transport in PN junction, Short channel nano transistor, Metal Oxide Semicondutor (MOS)FETs, Advanced MOSFETs, CMOS.

UNIT-III: Molecular Nanoelectronics

Electronic and Optoelectronic properties of molecular materieals, electrodes and contacts, functions, molecular electronic devices, Elementary circuits using organic molecules, organic material based rectifying diode switches, TFTs, OLEDs, OTFTs, Logic switches.

UNIT IV: Spintronics

Spintonics: Spin tunneling devices, Magnetic tunnel junctions, Tunneling spin polarization, Giant tunneling using MgO tunnel barrier, Giant Magnetro Resistance (GMR), Mott's two current model, GMR spin Value, Tunnel based spin injectors, Spin injection into a non-magnetic conductor, Spin transport in hybrid nanostructures, spin filters, spin diodes, Magnetic tunnel transistor, Memory devices: ferroelectric random access memory (RAM), Magnetic-RAMs. Spin-FETs, Spin-MOSFETs.

SUGGESTED READINGS

1. Edward L. Wolf: Nanophysics and Nanotechnology-An Introduction to Modern Concepts in Nanoscience
2. K. Goser, P. Glosekotter and J. Dienstuhl: Nanoelectronics and Nanosystems-From Transistors to Molecular and Quantum Devices
3. V. Mitin, V. Kochelap and M. Stroscio: Introduction to Nanoelectronics
4. Sadamichi Maekawa: Concepts in Spin Electronics
5. L. Banyai and S.W. Koch: Semiconductor Quantum Dots

Year: **Fifth (5th)**	Semester: **Tenth (X)**	Credit: **4**
Course Code: **B011010P**	Course Title: **PRACTICAL (NANOPHYSICS-II)**	

The institution may add / modify the experiments of the same standard, and in addition, can also propose the online Virtual Lab experiments.

1. Surface morphological characterization of nanomaterials by SEM
2. Surface morphological characterization of nanomaterials by TEM
3. Measurement and analysis of sample using FTIR
4. Measurement and analysis of UV-Vis absorption spectrum of nanomaterials
5. Measurement and analysis of photo luminescence - spectrum of nanomaterials
6. Measurement and analysis of Raman spectrum of nanomaterials
7. Measurement and analysis of photo luminescence/absorption spectrum of nanomaterials at low temperature
8. Structure characterization of nanomaterials by XRD and determination of average grain size, lattice parameters, etc.
9. Virtual Experiments, related to above experiments, from the Online Virtual Labs of Ministry of Education, Government of India

Year: **Fifth (5^{th})**	Semester: **Ninth (IX)**	Credit: **4**
	Semester: **Tenth (X)**	Credit: **4**
Course Code: **B010911R**	Course Title: **PG DISSERTATION IN PHYSICS**	
Course Code: **B011011R**		

The PG Dissertation In Physics will be based upon the guidelines laid by the University.