Sanjeev Agrawal Global Educational (SAGE) University, Bhopal

School of Sciences

M.Sc. (Physics)

I and II Year Syllabus

SESSION: 2020-21

M.Sc. PHYSICS

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

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

PEO1 Apply basic principles of Physics in understanding, analysis, and prediction of real world physical systems.

PEO2 Gain sufficient knowledge of theoretical and experimental techniques in Physics which essential for a promising career in academia, research and industry.

PEO3 Develop strong skills in research, analysis and interpretation of complex information.

PEO4 Successfully compete for employment in Electronics, Manufacturing and Teaching profession.

PEO5 Offer a wide range of experience in research methods, data analysis to meet the industrial needs.

PROGRAMME OUTCOMES (POs)

On completion of program, the student will be able to:

PO1 Apply the scientific knowledge to solve the complex physical problems.

PO2 Identify and analyze advanced scientific problems reaching substantiated conclusions using first principles of Mathematics, Physical, and Natural Sciences.

PO3 Use research-based knowledge and methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO4 Apply ethical principles and commit to the norms of scientific practice.

PO5 Communicate effectively on scientific activities with the Scientific/Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO6 Demonstrate knowledge and understanding of the scientific principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO7 Engage in independent and life-long learning in the broadest context of scientific and technological change.

PO8 Assess social issues (societal, health, safety, legal and cultural) and engineering problems.

PO9 Understand professional and ethical responsibility.

PO10 Develop cross cultural competency exhibited by working as a member or in teams.

DISTRIBUTION OF CREDITS ACROSS ALL COMPONENTS FOR M. SC. PHYSICS

Sem No.	Program Core (PC)	Discipline Specific Elective (DSE)	Project Based Learning (PBL)	Project	Total Credits
I	CC-I (4) CC-II (4) CC-III (4) CC-IV (4) CC-P1 (2) CC-P2 (2)	DSE-I (3)	2		**25**
II	CC-I (4) CC-II (4) CC-III (4) CC-IV(4) CC-P3(2) CC-P4(2)	DSE-II (3)	2		**25**
III	CC-I (4) CC-II (4) CC-III (4) CC-IV(4) CC-P5(4)	DSE-III (3)	2		**25**
IV		DSE/ MOOCS (4)		20	**24**
Total	**60**	**13**	**6**	**20**	**99**

SCHEME FOR M. SC. PHYSICS

Semester First																	
Course Code	**Course Title**	**Contact Hours per Week**			**Credits**	**ESE Duration (Hours)**	**Weightage (Theory)**						**Weightage (Practical)**			**Total**
		L	**T**	**P**			**MSE**	**ASG**	**TA**	**ATTD**	**ESE**	**TOT**	**CE^**	**ESE**	**TOT**	**GT**
PY20M101	Classical Mechanics	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
PY20M102	Quantum Mechanics-I	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
PY20M103	Mathematical Physics	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
PY20M104	Solid State Physics	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
Refer Table I	DSE-I	3	-	-	3	3	30	05	05	10	50	100	-	-	-	100
PY20M107	LAB- I	-	-	2	2	2	-	-	-	-	-	-	50	50	100	100
PY20M108	LAB- II	-	-	2	2	2	-	-	-	-	-	-	50	50	100	100
PB20M101	Project Based Learning-I	-	-	4	2	2	-	-	-	-	-	-	50	50	100	100
Total					**25**											**800**

^Two assessment by panel of expert

L-Lecture, T-Tutorial, P-Practical, ESE-End Semester Exam. MSE- Mid Semester Exam, ASG- Assignment, TA- Teacher's Assessment, ATTD-Attendance, TOT-Total, CE-Continuous Evaluation, GT- Grand Total

	Semester Second															
Course Code	Course Title	Contact Hours per Week			Credits	ESE Duration (Hours)	Weightage (Theory)						Weightage (Practical)			Total
		L	T	P			MSE	ASG	TA	ATTD	ESE	TOT	CE^	ESE	TOT	GT
PY20M201	Quantum Mechanics- II	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
PY20M202	Electromagnetic Theory	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
PY20M203	Statistical Mechanics	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
PY20M204	Atomic and Molecular Physics	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
Refer Table II	DSE- II	3	-	-	3	3	30	05	05	10	50	100	-	-	-	100
PY20M207	LAB- III	-	-	2	2	2	-	-	-	-	-	-	50	50	100	100
PY20M208	LAB- IV	-	-	2	2	2	-	-	-	-	-	-	50	50	100	100
PB20M201	Project Based Learning- II	-	-	4	2	2	-	-	-	-	-	-	50	50	100	100
Total					**25**											**800**

^Two assessment by panel of expert

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	Semester Third																
Course Code	**Course Title**	**Contact Hours per Week**			**Credits**	**ESE Duration (Hours)**	**Weightage (Theory)**						**Weightage (Practical)**			**Total**
		L	**T**	**P**			**MSE**	**ASG**	**TA**	**ATTD**	**ESE**	**TOT**	**CE^**	**ESE**	**TOT**	**GT**
PY20M301	Nuclear and Particle Physics	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
PY20M302	Digital Circuits and Design	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
PY20M303	Plasma Physics	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
PY20M304	Quantum Field Theory	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
Refer Table III	DSE- III	3	-	-	3	3	30	05	05	10	50	100	-	-	-	100
PY20M307	LAB- V	-	-	8	4	2	-	-	-	-	-	-	100	100	200	200
PB20M301	Project Based Learning-III	-	-	4	2	2	-	-	-	-	-	-	50	50	100	100
Total					**25**											**800**

^Two assessment by panel of expert

L-Lecture, T-Tutorial, P-Practical, ESE-End Semester Exam. MSE- Mid Semester Exam, ASG- Assignment, TA- Teacher's Assessment, ATTD-Attendance, TOT-Total, CE-Continuous Evaluation, GT- Grand Total

	SemesterFourth																
Course Code	**Course Title**	**Contact Hours per Week**			**Credits**	**ESE Duration (Hours)**	**Weightage (Theory)**						**Weightage (Practical)**			**Total**
		L	**T**	**P**			**MSE**	**ASG**	**TA**	**ATTD**	**ESE**	**TOT**	**CE^**	**ESE**	**TOT**	**GT**
Refer Table- IV	DSE-IV/ MOOCs- I	4	-	-	4	3	30	05	05	10	50	100	-	-	-	100
PY20M402	Project	-	-	20	20	2	-	-	-	-	-	-	250	250	500	500
Total					**24**											**600**

^Two assessment by panel of expert

L-Lecture, T-Tutorial, P-Practical, ESE-End Semester Exam. MSE- Mid Semester Exam, ASG- Assignment, TA- Teacher's Assessment, ATTD-Attendance, TOT-Total, CE-Continuous Evaluation, GT- Grand Total

LIST OF DISCIPLINE SPECIFIC ELECTIVES (DSE)

Table 1: Semester One(DSE- I)		
S.No.	**Course Code**	**Course Title**
1.	**PY20M105**	Computer Applications in Physics
2.	**PY20M106**	Atmospheric Physics

Table 2: Semester Second(DSE- II)		
S.No.	**Course Code**	**Course Title**
1.	**PY20M205**	Communication Electronics
2.	**PY20M206**	Astronomy and Astrophysics

Table 3: Semester Third(DSE- III)		
S.No.	**Course Code**	**Course Title**
1.	**PY20M305**	Digital Circuits and Fundamental of Microprocessor
2.	**PY20M306**	Group Theory for Physics

Table 4: Semester Fourth(DSE- IV)		
S.No.	**Course Code**	**Course Title**
1.	**PY20M401**	General Theory of Relativity and Cosmology
2.	**PY20M402**	Nano Science and Nanotechnology
		MOOCs-I

Syllabus

SEMESTER I

Core Course I

COURSE CODE	CLASSICAL MECHANICS	Total Lec.:60
PY20M101		**4-0-0**
Learning Objectives:	• Students will demonstrate conceptual understanding of the basic principles of Classical Mechanics. • Students will demonstrate the ability to apply basic methods of Classical Mechanics towards solutions of various problems • To represent the equations of motion for complicated mechanical systems using the Lagrangian and Hamiltonian formulation. • To demonstrate knowledge and understanding of the concepts the dynamic system of particles.	
Pre-requisite:	Elementary idea about Newton's laws and with basic physics concepts such as mass, moments of inertia, length, force and time along with geometry, algebra, and calculus.	
UNIT	**CONTENT**	**HOURS**
I	Mechanics of a single & system of particle, Rocket equation, generalized coordinates, Galileo's relativity principle, D'Alembert Principle, Calculus of variation and Hamilton's variational principle, Laws of conservation as derived from homogeneity and isotropy of space and homogeneity of time and principle of conservation of energy.	12
II	Constraint, Holonomic and non-Holonomic, Lagrangian and Hamiltonian formalism, Lagrangian for a free particle and system of particles, Euler Lagrange equations of motion, Hamilton's equation of motion, Reduced mass, Similarity, Virial theorem.	12
III	Scattering in the central field, Scattering cross section, Rutherford formula, Elastic and inelastic collision, Small oscillations, Normal coordinates and its application, Forced oscillation, Frequency of molecular vibration, Damped oscillation, Parametric resonance, Coupled oscillators and other simple systems, Canonical variables, Poisson's bracket, Jacobi identity.	12
IV	Degrees of freedom, Motion of rigid body, Euler's angle, Moment of Inertia tensors, Angular momentum of a rigid body, Coriolis force, Eulerian coordinates and equations of motion for a rigid body, Symmetric and asymmetric top, Non-inertial frames and Pseudoforces.	12
V	Canonical transformations, Generation of infinitesimal canonical transformation, Symmetry principle and conservation laws, Hamilton Jacobi theory, Action angle variables, Centre of mass and Laboratory systems, Kepler problem, Precessing orbits.	12
	Course Outcomes as per Bloom's Taxonomy	
CO1	The student will be able to **define**[1] and understand basic mechanical concepts related to discrete and continuous mechanical systems.	
CO2	The student will able be to **describe**[2] the vibrations of discrete and continuous mechanical systems.	
CO3	They will able be to **describe**[2] planar and spatial motion of a rigid body.	
CO4	They will able be to **understand**[2] the motion of a mechanical system using Lagrange-Hamilton formalism.	
CO5	They will able be to **solve**[3] problems using their knowledge and skills in Modern Physics. They will use critical thinking skills to formulate and solve quantitative problems in Applied Physics.	
Text Books:	• H. Goldstein, Classical Mechanics, 3rd edition, Pearson Education, 2011. • R.G. Takwale, P. S. Puranik, Introduction to Classical Mechanics, Tata McGraw-Hill Education, 1988. • N. Rana and P.Joag,Classical Mechanics, McGraw Hill Education, 2017.	
Reference Books:	• D. Morin, Introduction to Classical Mechanics with Problems and Solutions, Cambridge University Press, 2008. • R.D. Gregory, Classical Mechanics, Cambridge University Press, 2006. • W. Greiner, Classical Mechanics: Systems of Particles and Hamiltonian Dynamics, 2nd Edition, Springer, 2010.	

Core Course II

COURSE CODE	QUANTUM MECHANICS I	Total Lec.:60
PY20M102		4-0-0
Learning Objectives:	• The main objective of this course is to make students aware about the basic formulations in quantum mechanics. • The course takes up the responsibility to give information about Green function and their application to solve inhomogeneous differential equations • Students will be given knowledge about unitary transformations, dirac delta function, matrix representation of operators and their applications • Main focus is on angular momentum operator and their representation in spherical coordinates. • Students will be given insight to various approximation methods.	
Pre-requisite:	Working knowledge of calculus and linear algebra, Partial Differential Equations and Ordinary Differential Equations and linear algebra.	

UNIT	CONTENT	HOURS
I	Abstract formulation of Quantum Theory, Reviews of quantum postulates, Linear vector space, Dirac notations of Bra-Ket notation, Eigen values and Eigen vectors, Orthonormality, Completeness, Closure, Matrix representation of observables and states, Determination of Eigenvalues and Eigenstate for observables using matrix representations,Generalized uncertainty principle, Change ofrepresentation and Unitary transformations, Coordinate and momentum representations, Ehrenfest theorem.	12
II	Theory of Angular Momentum, Equations of motion in Schrodinger and Heisenberg pictures, Symmetry, Invariance and conservation laws, Relation between rotation and angular momentum, Commutation rules, Matrix representations, Addition of angular momenta and Clebsch-Gordon coefficients, Pauli spin matrices.	12
III	Green's Functions, Green's function method of solving inhomogeneous differential equations, Boundary Conditions, Application to one dimensional problem.	12
IV	Scattering Theory, Differential and total Scattering Cross-sections laws, Partial wave analysis and application to simple cases; Integral form of scattering equation, Born approximation validity and Simple applications.	12
V	Approximation Methods,Time independent Perturbation theory (non-degenerate and degenerate) and applications to fine structure splitting, Zeeman effect (Normal and anomalous), Stark effect, Vibrational method and applications to helium atom; WKB approximation and applications to simple cases. Time dependent Perturbation theory, Fermi's Golden rule, Semi-classical theory of interaction of atoms with radiation.	12

Course Outcomes as per Bloom's Taxonomy	
CO1	The student will be able to **explain**[1] idea about non-relativistic quantum mechanics
CO2	They will able be to **understand**[2]concept of Schrödinger equation and related problems
CO3	They will able be to **utilize**[3]Quantum mechanical axioms and the matrix representation of quantum mechanics
CO4	They will able be to **summarize**[2]Approximate methods for solving the Schrödinger equation
CO5	They will able be to **solve**[3]Spin, angular momentum states, angular momentum addition rules, and identical particles
Text Books:	• P.W. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, 2nd Edition, Tata McGraw Hill, 2017. • Ghatak and Loknathan,Quantum Mechanics - Theory and Applications, 5th Edition, Laxmi Publications, 2015. • J.J, Sakurai, Advanced Quantum Mechanics, Pearson Publishers, 1967.
Reference Books:	• L. I. Schiff, Quantum Mechanics, 4th Edition, McGraw Hill Education, 2017. • D.J. Griffiths, Introduction to Quantum Mechanics, Cambridge University Press, 2019. • P.A.M. Dirac, ThePrinciples of Quantum Mechanics, 4th Edition, Oxford Science Publications, 1981.

Core Course-III

COURSE CODE	MATHEMATICAL PHYSICS		Total Lec.:60
PY20M103			**4-0-0**
Learning Objectives:	• Understand the linear equations, vector spaces, matrices, linear transformations, determinants, eigenvalue, eigenvectors, etc. • Learn to use Laplace transform methods to solve differential equations. • Introduce the Fourier series and its application to the solution of partial differential equations.		
Pre-requisite:	Elementary idea of Vector algebra and Calculus, differential equation and sine and cosine functions.		
UNIT	**CONTENT**	**HOURS**	
I	Theory of Functions of a Complex Variable: Introduction and physical significance of Complex Variables, Cauchy Riemann conditions, analytic function, line integrals, Cauchy integral formula, derivatives of analytical functions and fundamental theorem of algebra. Taylor's series, Laurent's series, integration and differentiation of power series, zeros of analytical functions, singular points, residues, Cauchy's residue theorem,poles,Jordan's Lemma; Evaluation of definite integrals,Principal Value, Bromwitch contour integrals.	12	
II	Differential Equations: Differential Equations: Solution of differential equation in series, Legendre, Bessel, Hermite, Leaguers, functions and their generating functions, Recurrence relations and orthogonal properties, Confluent Hypergeometric functions, Laplace, Poisson and wave equations and their solutions with boundary conditions.	12	
III	Fourier and Laplace Transforms: Fourier transform and its properties, Properties and Representations of Dirac Delta Function, Transforms of derivatives, Parseval's Theorem, Convolution Theorem, Momentum representation, Laplace transform and its Properties, Convolution theorem and its applications, Laplace transform method of solving differential equations.	12	
IV	Tensors: Tensor-notations and conversions, Contravariant tensors, Rank of the tensors, properties of the tensors, contraction, Cartesian tensors and their transformation properties, Eigen value of second rank tensor, Quotient law, Higher rank tensor with example from piezoelectricity, stiffness and compliance	12	
V	Group Theory:Concept of a group (additive and multiplicative), Matrix representation of a group, Reducible and irreducible representation of a group,The Great Orthogonal ity Theorem.	12	
Course Outcomes as per Bloom's Taxonomy			
CO1	The student will be able to **Recall**[1] about fundamental theory of complex variable and its application in Physics.		
CO2	They will be able to **Interpret**[2] different ways of solving differential equations and familiarized with singular points and Frobenius method.		
CO3	They will be able to **make use of**[3] Fourier and Laplace transforms, their inverse transforms in Physics.		
CO4	They will be able to **explain**[2] the physical law in terms of tensors, and simplify it by use of coordinate transforms.		
CO5	They will be able to **solve**[6] problem related with basic of Group Theory		
Text Books:	• Young Hugh D. and Freedman Roger, University Physics with Modern Physics, 4th edition, Pearsons Publishing, 2017. • H.K. Das and Rama Verma, Mathematical Physics, S Chand Publishing, 2018. • Arfken, Webber and Harris, Mathematical Methods for Physicists, 7th edition, Elsevier Publishings, 2012.		
Reference Books:	• Louis Pipes, Applied Mathematics for Engineers and Physicists, 3rd Revised edition, Dover Publications Inc., 2014. • H.W. Wyld, Mathematical Methods for Physics, 1st edition, Westview Press, 1999. • M.L. Boas, Mathematical Methods in the Physical Sciences, Wiley, 1984.		

Core Course-IV

COURSE CODE	SOLID STATE PHYSICS	Total Lec.:60
PY20M104		**4-0-0**
Learning Objectives:	• Give review of basic theories of solid state structure to students. • Application of solid state theory to describe physical behavior of solids and electronic devices. • Students will gain knowledge of basic theories of the electronic structure of materials. • Provide Basic understanding of symmetry, electronic and thermodynamic properties of solid state systems and their technological applications.	
Pre-requisite:	Good grasp of quantum mechanics and elementary idea about crystal structure	
UNIT	**CONTENT**	**HOURS**
I	Crystal symmetry, Symmetry elements in crystals, Point groups, Space groups, Bravais space lattices, Crystal defects, Imperfections in crystals, Production of defects, Crystal binding, Different types of crystal bindings, Cohesive energy, Calculation of cohesive energycalculation of lattice energy of ionic crystals, Madulang constant of ionic crystals, Reciprocal, Reciprocal lattices of simple cubic structure, Bravais lattices, Ewald construction, Bragg condition, Concept of Brillouin zone, Structure factor, Atomic form factor, X ray diffraction technique, Electron scattering, Neutron scattering, Elements of Quasi Crystals.	12
II	Vibrations of monatomic and diatomic lattices, Normal modes and phonons, Quantization of lattice vibrations, Phonon momentum, Elastic scattering of neutrons by phonons, Einstein model of specific heat , Density of modes, Debye model, Anharmonic crystal interactions, Thermal expansion, Normal and Umklapp process, Thermal conductivity, Macroscopic field, Depolarization field, Local electronic field, Clausius-Mossotti relation, Sources of polarisability, Dielectric relaxation and loss, Ferroelectric crystals, Piezoelectricity.	12
III	Diamagnetism, Paramagnetism, Origin of magnetic dipoles, Larmor precession, Quantum theory of paramagnetism, Curie law, Introduction to superconductivity, Electromagnetic properties, Meissner effect, Types of super conductors, Thermal properties, Microwave and infrared properties, Isotope effect, Josephson effect, Elements of super fluidity, BCS theory.	12
IV	Fermi-Dirac distribution, Quantum theory of free electron gas, Density of states, Fermi energy, Electrical conductivity, Thermal conductivity, Wiedemann-Franz law, Paramagnetism of conduction electrons in metals, Electronic specific heat, Hall effect, Bloch theorem, Energy bands, Kronig-Penny model, Different models (elementary ideas only), The nearly free electron model, Tight-binding model, Motion of electrons in one dimension, Concept of effective mass and holes, Distinction between metals, Insulators and semiconductors.	12
V	Frenkel and Schottky defects, Defects by non-stoichiometry, Electrical conductivity of ionic crystals, Classifications of dislocations, Role of dislocations in plastic deformation and crystal growth, Colour centers and photoconductivity, Luminescence and phosphors, Alloys, Hume-Rothery rules, Electron compounds, Bragg - Williams theory, Order-disorder phenomena, Superstructure lines, Extra specific heat in alloys.	12
	Course Outcomes as per Bloom's Taxonomy	
CO1	The student will be able to **classify**[2]different Lattice types and explains the concepts of reciprocal lattice and crystal diffraction.	
CO2	They will be able to **predict**[6] electrical and thermal properties of solids and explain their origin.	
CO3	They will be able to **describe**[2]the di-electric properties of insulators.	
CO4	They will be able to **explain**[2] superconductivity, its properties, important parameters related to possible applications**.**	
CO5	They will be able to **explain**[2] various types of dislocations in plastic deformation and crystal growth.	

Text Books:	• C. Kittel, Introduction to Solid State Physics, 8th Edition, Wiley Publishers, 2012. • M. A. Wahab, Esssentials of Crystallography, 2nd Edition Revised, Alpha Science International, 2014. • M. Ali Omar, Elementary Solid State Physics, 1st Edition, Pearson Publishers, 2002.
Reference Books:	• P. Hofmann, Solid State Physics: An Introduction, 2nd Edition Wiley-VCH Publishing, 2008. • L.V. Azaroff, Elements of X-ray Crystallography, McGraw hill publishers, 1968. • J. S. Blakemore, Solid State Physics, 2nd Edition, Cambridge University Press, 1985.

Discipline Specific Electives I

COURSE CODE	COMPUTER APPLICATION IN PHYSICS	Total Lec.:45
PY20M105		3-0-0
Learning Objectives:	• To encourage students to "discover" physics in a way how physicists learn by doing research. • To address analytically intractable problems in physics using computational tools. • To enhance the various computational technique with programming basic in C to face the world of problems using high performance iteration techniques. • To show how physics can be applied in a much broader context than discussed in traditional curriculum.	
Pre-requisite:	None.	
UNIT	**CONTENT**	**HOURS**
I	Computer fundamentals, CPU, Memory, I/O units, Information representation, Integral and real number representation, Character representation, Alphanumeric codes, BCD, Gray, ASCII codes, Error detection and error correcting codes, Hamming codes, CRC codes.	9
II	Computer Software and Operating Systems, System software and application software, Translator programs, Loaders and linkers, Operating systems and their classification, Elements of DOS and Windows basic commands.	9
III	Elements of C Programming Language, Algorithms and flowchart, Structure of a high level language program, Features of C language, Constants and variables, Expressions, Input and output statements, Conditional and loop statements, Arrays, Functions, Character strings, Structures, Pointer data type, List and tree.	9
IV	CPU- programmers model, Instruction set and addressing modes of a generic CPU, RISC and SISC, Storage System-primary and secondary memory, Semiconductor, Magnetic and optical memory, Cache memory, Virtual memory, Memory management, IO Units, Computer Networks, Internet structure, TCP/IP protocol, Internet services, Introduction to WWW.	9
V	MatLab programming, Symbolic & numerical calculations, Graphics, 3D plots, Equation solving, Matrices, Mathematical relations, Complex numbers, Simplifications, Algebraic expressions, Mathematical operations, Inbuilt functions, Differentiation, Integration, Series and limits.	9
Course Outcomes as per Bloom's Taxonomy		
CO1	The student will be able to **understand**[2] the basic idea about finding solutions using computational methods basics.	
CO2	They will be able to learn how to **interpret**[3] and **analyze**[4] data visually, both during and after computation.	
CO3	The student will be able to **correlate**[4]the basic computation processes and optimization of data.	
CO4	The student will be able to acquire a working knowledge of basic research methodologies, data analysis and **interpretation**[3].	
CO5	The student will be able to **simulate**[6] the computational applications with Physics based aspects.	
Text Books:	• Andrew S. Tanenbaum, and Herbert Bos, Modern Operating Systems, 4th Edition, Pearson Publishers, 2016. • E. Balagurusamy, Programming in ANSI C, 7th Edition, Mc-graw Hill Publication, 2017. • Amos Gilat, MATLAB: An Introduction with Applications, 4th Edition, Wiley Publishers, 2012.	
Reference Books:	• Andrew S. Tanenbaum, and David J. Wetherall, Computer Networks, 5th Edition, Pearson Publishers, 2013. • Mano M. Morris, Computer System Architecture, 3rd Edition, Pearson Publishers, 2017. • Byron Gottfried, Programming with C (Schaum's Outline Series), Mc-graw Hill Publications, 2017.	

Discipline Specific Electives I

COURSE CODE	ATMOSPHERIC PHYSICS		Total Lec.:45
PY20M106			**3-0-0**
Learning Objectives:	• To provide a keen knowledge on atmospheric behavior, description of air, stratification of mass, trace constituents, radiative equilibrium of the planet. • To provide a deep insight on physics of atmosphere, aerosols and clouds. • To understand the Short wave and long wave radiation, radiometric, lamberts equation, radioactive heating, thermal relaxation and green house effect.		
Pre-requisite:	None.		
UNIT	**CONTENT**		**HOURS**
I	Elementary concepts of atmospheric sciences, Vertical thermal structure and composition of the atmosphere hydrostatics of the atmosphere, Geopotential, Equipotential surface, Hydrostatic equation, Hydrostatic equilibrium, Standard atmosphere, Altimetry.		9
II	Gas laws and their application to the atmosphere, Equation of state for dry and moist air, Humidity parameters, Virtual temperature, First and second laws of thermodynamics, Specific heats of gases, Internal energy, Adiabatic processes, Potential temperature, Revisiting entropy, Reversible and irreversible processes, Carnot's cycle, Thermodynamics of water vapour, Latent heat, Clausius-Clapeyron equation.		9
III	Thermodynamics of the atmosphere, Dry adiabatic lapse rate, Case of unsaturated moist air, Saturated adiabatic lapse rate, Pseudo-adiabatic cases, Equivalent potential temperature, Wet-bulb temperature, Wet-bulb potential temperature and saturation potential temperature, Normand's propositions and Normand point.		9
IV	Atmospheric instability and convection-stability criteria, Parcel method, Brunt-Vaisala oscillations, Lifting; mixing and convective condensation levels, Potential instability and latent instability, Stability indices, Slice method of stability analysis, Cloud formation and types, Principles of thermodynamic diagrams and various thermodynamic diagrams.		9
V	Radiation, Laws of black body radiation, Radiation transfer, Solar radiation, Latitudinal and seasonal variation, Passage through the atmosphere, Absorption, Scattering and reflection, Mean disposition of solar radiation, Terrestrial radiation, Absorption in the atmosphere, Raleigh and Mie scattering, Atmospheric window.		9
Course Outcomes as per Bloom's Taxonomy			
CO1	The student will be able to **understand**[2] and **acquire**[1] knowledge of the phenomena in earth's atmosphere governed by physical laws.		
CO2	They will be able to **determine**[3] and achieve basic inputs for the global circulation of atmosphere.		
CO3	They will be able to **create**[6] a scope to identify and **evaluate**[5] new areas of research in the field of atmospheric science.		
CO4	They will be able to **summarize**[2] the effect of radiation and their principles involving the atmospheric phenomena.		
CO5	They will be able to **identify**[1]the parameters which governs the different aspects of atmospheric physics.		
Text Books:	• S.L. Hess, Introduction to theoretical Meteorology, Krieger Publishing Company, 2006. • D.G. Andrews, The Introduction to Atmospheric Physics, 2nd Edition, Cambridge University Press, 2010.		

	• J. Houton, The Physics of the Atmospheres, 3rd Edition, Cambridge University Press, 2002.
Reference Books:	• J.M. Wallace, and P. V. Hobbs, Atmospheric Science: An Introductory Survey, 2nd edition, Elsevier Academic Press, 2006. • J. Marshall, and R. A. Plumb, Atmosphere Ocean and Climate Dynamics: An Introductory Text, Elsevier Academic Press, 2008. • R.S. Lindzen, Dynamics in Atmospheric Physics, Cambridge University Press, 2008.

Practical Paper

<table>
<tr><th>COURSE CODE</th><th>PRACTICE LAB I</th><th>Practicals: 60</th></tr>
<tr><td>PY20M107</td><td colspan="2" align="right">2</td></tr>
<tr><td></td><td colspan="2">1: To Find the capacitance of a cylindrical capacitor.
2. To study and verify Compton Effect.
3. To study and verify Electron Spin Resonance.
4. To verify the Hall Effect and measure the Hall coefficient.
5. To study the Atomic Spectra of two-Electron Systems.
6. To calculate the Dissociation Energy of I_2 molecule.
7. To verify the Zeeman Effect.
8. To verify the Faraday Effect and Kerr Effect.
9. To find out the Ionization potential of Lithium.
10. To verify the Frank-Hertz experiment.</td></tr>
</table>

<table>
<tr><th>COURSE CODE</th><th>PRACTICE LAB II</th><th>Practicals: 60</th></tr>
<tr><td>PY20M108</td><td colspan="2" align="right">2</td></tr>
<tr><td></td><td colspan="2">1: First order Numerical differentiation of a given function.
2. Numerical Integration of a given function using Simpson’s method.
3. Numerical Integration of a given function using Gaussian quadrature method.
4. Lagrange’s forward and backward interpolation application on agiven data.
5. Finding solution of first order differential equation using Runge-Kutta method.
6. Matrix Diagonalization by Jacobi method.
7. Finding Inverse of a given matrix.
8. Finding eigenvalue and eigenvector of a given matrix.</td></tr>
</table>

Project Based Learning I

COURSE CODE	PROJECT BASED LEARNING
PB20B101	
Learning Objectives:	• Integrating the knowledge and skills of various courses on the basis of multidisciplinary projects. • Develop the skill of critical thinking and evaluation. • To develop 21st century success skills such as critical thinking, problem solving, communication, collaboration and creativity/innovation among the students. • To enhance deep understanding of academic, personal and social development in students. • Employ the specialized vocabularies and methodologies.
General Guidelines:	• PBL will be an integral part of UG/PG Programs at different levels. • Each semester offering PBL will provide a separate Course Code, two credits will be allotted to it. • Faculty will be assigned as mentor to a group of 30 students minimum by HoS. • Faculty mentor will have 4 hours/week to conduct PBL for assigned students. • Student will select a topic of their choice from syllabus of any course offered in respectiveSemester (in-lines with sustainable development goals). • Student may work as a team maximum 3 or minimum 2 members for single topic. • For MSE, student's performance will be assessed by panel of 2 experts either from other Department/school, or from same department/school based on chosen topic. This will becomprised of a presentation by student followed by viva-voce. It will be evaluated for 30 marks. • 20 marks would be allotted for continuous performance assessment by concerned guide/mentor. • For ESE, student will need to submit a project report in prescribed format, duly signed by concerned guide/mentor and head of the school. The report should be comprised of followingcomponents: 1. Introduction 2. Review of literature 3. Methodology 4. Result and Discussion 5. Conclusion and Project Outcomes 6. References • In ESE, viva-voce of students will be conducted on the basis of report, by one external and one internal faculty which is of 50 Marks. Student will need to submit three copies for 1. Concerned School 2. Central Library 3. Self. The integrity of the report should be maintained by student. Any malpractice will not be entertained. • Writing Ethics to be followed by student, a limit of 10 % plagiarism is permissible. Plagiarism report is to be attached along with the report. • Project could be a case study/ analytical work /field work/ experimental work/ programming or as per the suitability of the program.

Syllabus

SEMESTER II

Core Course I

COURSE CODE	QUANTUM MECHANICS II		Total Lec.:60
PY20M201			
Learning Objective:	• Course will provide elementary idea about WKB approximation. • The study of scattering theory in laboratory, elementary idea about scattering cross section and amplitude. • Idea about symmetric and anti-symmetric wave function and its application. • Study of relativistic Quantum mechanics and associated principle.		
Pre-requisite:	Basic idea of Quantum mechanics.		
UNIT	**CONTENT**		**HOURS**
I	WKB Approximation, Quantization rule, Tunneling through a barrier, Qualitative discussion of α-decay, Time dependent perturbation theory, Interaction picture, Constant and harmonic perturbations, Fermi's Golden rule, Sudden and adiabatic approximations.		12
II	Scattering in Laboratory and Centre of mass frames, Differential and total scattering cross-sections, Scattering amplitude, Scattering by spherically symmetric potentials, Partial wave analysis and phase shifts, Ramsauer-Townsend effect, Relation between sign of phase shift and attractive or repulsive nature of the potential, Scattering by a rigid sphere and square well, Coulomb scattering, Formal theory of scattering, Green's function in scattering theory, Lippman-Schwinger equation, Born approximation.		12
III	Symmetries in quantum mechanics, Conservation laws and degeneracy associated with symmetries, Continuous symmetries, Space and time translations, Rotations, Rotation group, Homomorphism between SO(3) and SU(2), Explicit matrix representation of generators for j=1 and j=1, Rotation matrices, Irreducible spherical tensor operators, Wigner-Eckart theorem, Discrete symmetries, Parity and time reversal.		12
IV	Identical Particles, Meaning of identity and consequences, Symmetric and anti-symmetric wave functions, Slater determinant, Symmetric and anti-symmetric spin wave functions of two identical particles, Collisions of identical particles.		12
V	Relativistic Quantum Mechanics, Klein-Gordon equation, Feynman-Stuckelberg interpretation of negative energy states and concept of antiparticles, Dirac equation, Covariant form, Adjoint equation, Plane wave solution and momentum space spinors, Spin and magnetic moment of the electron, Non-relativistic reduction, Helicity and chirality, Properties of γ matrices, Charge conjugation,Normalization and completeness of spinors.		12
Course Outcomes as per Blooms Taxonomy			
CO1	Student will be able to **understand**^{2} various approximation techniques in Quantum Physics.		
CO2	They will be able to **demonstrate**^{2} the phenomena of scattering in various frames of references and related theories.		
CO3	They will be able to s**implify**^{2}symmetry theory in quantum mechanics		
CO4	They will be able to i**nterpret**^{4}concept of Symmetric and anti-symmetric wave functions.		
CO5	They will be able to **idenfity**^{2}possible application of Relativity in quantum theory.		
Text Books:	• J. J. Sakurai, Advanced Quantum Mechanics, 1st Edition, Pearson Publishers, 2002. • Franz Mandl and Graham Shaw, Quantum Field Theory, 2nd Edition, Wiley Publishers, 2010. • Satya Prakash, Advanced Quantum Mechanics, KNRN Publishers, 2012.		
Reference Books:	• James D. Bjorken, Sidney D. Drell, Relativistic Quantum Mechanics, Customized Edition, Primis Custom Publishing, 2008. • R. Shankar, Principles of Quantum Mechanics, 2nd Edition, Springer, 2008. • F. Schwabl, Advanced Quantum Mechanics, 4th Edition, Springer, 2008.		

Core Course-II

COURSE CODE	ELECTROMAGNETIC THEORY	Total Lec.: 60
PY20M202		**4-0-0**
Learning Objectives:	• To introduce the basic Mathematical concepts related to Electromagnetic vector fields. • To impart knowledge on the concepts of Electrostatics, Electric potential, Energy density and their applications. • To impart knowledge on the concepts of magnetostatics, magnetic flux density, scalar and vector potential and its applications. • To impart knowledge on the concepts of Faraday‘s law, induced EMF and Maxwell‘s equations, Electromagnetic waves and Transmission lines.	
Pre-requisite:	Basics principle of electromagnetic theory and relativity.	
UNIT	**CONTENT**	**HOURS**
I	Review of Maxwell’s equation, Fundamental problem of electrodynamics, Scalar and vector potentials, Gauge transformations, Coulomb and Lorentz gauges.	12
II	Relativistic mechanics, Special theory of Relativity, Concepts of invariant interval, Light cone, Event and world line, Four vectors, tensors, Lorentz transformation as 4-vector transformationsm, Transformation properties of electric and magnetic fields, E.M. field tensor, Covariance of Maxwell’s equations.	12
III	Motion in uniform static magnetic and static electric field, Motion in crossed electric and magnetic fields, Motion of particle in cross electric and magnetic fields, Drift of particle on non-uniform static magnetic fields, Adiabatic invariance of magnetic moments of a charged particle and Torus principle of magnetic field.	12
IV	Green function for relativistic wave equation, Radiation form localized oscillating charges, Near and far zone fields, Multipole expansion, Dipole and quadrupole radiation, Center fed linear antenna, Radiation from an accelerated point charge, Lienard – Wiechert potential, Power radiated by a point charge, Lienard’s formula and its nonrelativistic limit (Larmor’s formula), Angular distribution of radiated power for linearly and circularly accelerated charges.	12
V	Lagrangian for a free relativistic particle, Lagrangian for a charged particle in an E.M. field, Lagrangian for interacting charged particles and fields, Energy momentum tensor and related conservation laws.	12
	Course Outcomes as per Bloom’s Taxonomy	
CO1	Students will be able to **understand**^{2} the basic concept of fundamental problems in electrodynamics.	
CO2	They will be able to **apply**^{3} the principles of relativistic mechanics to analyse electric and magnetic field tensors.	
CO3	They will be able to **demonstrate**^{2} the motion of charged particles in various electromagnetic conditions	
CO4	They will be able to **outline**^{2} concept of radiation under different conditions	
CO5	They will be able to **utilize**^{3}Lagrangian for a charged particle in an E.M. field	
Text Books:	• D.J. Griffiths, Introduction to Electrodynamics, 4th Edition, Pearson Publishers, 2012. • J.D.Jackson, Classical Electrodynamics, 3rd Edition, Wiley publishers, 2007 • M. Schwartz, Principles of Electrodynamics, Dover Publication, 1987. • M.N.O. Sadiku, Elements of Electromagnetics, 3rd Edition, Oxford University Press, 2000.	
Reference Books:	• J.A. Bittencourt, Fundamentals of Plasma Physics, 3rd Edition, Springer, 2004. • H.J.W. Mueller-Kirten, Electrodynamics: An Introduction including Quantum Effects, World Scientific, 2004. • F.F. Chen, Introduction to Plasma Physics and Controlled Fusion, 3rd Edition, Springer, 2015.	

Core Course-III

COURSE CODE	STATISTICAL MECHANICS	Total Lec.: 60
PY20M203		4-0-0
Learning Objectives:	• This course provides an introduction to the microscopic formulation of statistical mechanics. • Course will able to explore the general principles, from which emerge an understanding of the microscopic significance of entropy and temperature. • To give elementary idea about microscopic models of many-particle systems with measurable quantities.	
Pre-requisite:	Knowledge of quantum and Classical Physics Elementary idea of calculus	
UNIT	**CONTENT**	**HOURS**
I	Central Limit Theorem,Macrostates, microstates, Phase space and ensembles, Ergodic hypothesis, Postulate of equal a priori probability and equality of ensemble average and time average, Boltzmann's postulate of entropy, Counting the number of microstates in phase space, Entropy of ideal gas, SackurTetrode equation and Gibbs' paradox, Liouville's Theorem.	12
II	System in contact with a heat reservoir, Expression of entropy, Canonical partition function, Helmholtz free energy, Fluctuation of internal energy, System in contact with a particle reservoir, Chemical potential, Grand canonical partition function and Grand potential, Fluctuation of particle number, Chemical potential of ideal gas, Chemical equilibrium and SahaIonisation Equation, Mean field theory and Van der Wall's equation of state, Cluster integrals and Mayer-Ursell expansion.	12
III	Density Matrix, Quantum Liouville theorem, Density matrices for microcanonical, Canonical and grand canonical systems, Simple examples of density matrices, One electron in a magnetic field, Particle in a box, Identical particles, B-E and F-D distributions, Equation of state, Bose condensation, Equation of state of ideal Fermi gas, Fermi gas at finite T.	12
IV	Phase Transition and Critical Phenomeona, Ising model, Partition function for one dimensional case, Chemical equilibrium and Sahaionisation formula, Phase transitions, First order and continuous critical exponents and scaling relations, Calculation of exponents from Mean Field Theory and Landau's theory, Upper critical dimension.	12
V	Non-equilibrium Statistical Mechanics, Irreversible processes, Classical Linear Response Theory, Brownian motion, Master Equation, Fokker- Planck Equation.	12
	Course Outcomes as per Bloom's Taxonomy	
CO1	Students will be able to **define**[1] the concepts and roles of entropy and free energy from the view point of Statistical mechanics.	
CO2	They will be able to **apply**[3] the machinery of Statistical mechanics to the calculation of macroscopic properties resulting from microscopic models of magnetic and crystalline systems.	
CO3	They will be able to **define**[1]Fermi-Dirac and Bose-Einstein distributions; state where they are applicable.	
CO4	They will be able to **categorize**[3]the phenomena of Phase transition of first and continuous order.	
CO5	They will be able to **discuss**[4]the classical Linear response theory for non-equilibrium Quantum theory.	
Text Books:	• J. W. Gibbs, Elementary Principles in Statistical Mechanics, Revised edition, Dover Publications Inc., 2014 • K. Huang, Statistical Mechanics, 2nd Edition, Wiley Publishers, 2008. • R.K. Pathria, and P. D. Beale, Statistical Physics, 3rd Edition, Elsevier, 2011.	
Reference Books:	• D. Chandler, Introduction to Modern Statistical Mechanics, Oxford University Publishing, 1987. • L.D. Landau and E. M. Lifshitz, Statistical Physics: Volume 5, 3rd Edition, Butterwoth-Heinemann Publishing, 1996. • Shang-Keng Ma, Statistical Mechanics, World Scientific Publishing Co. Pvt. Ltd., 1985.	

Core Course-IV

COURSE CODE	ATOMIC AND MOLECULAR PHYSICS	Total Lec.: 60
PY20M204		**4-0-0**
Learning Objectives:	• To study atomic systems and their interaction with electromagnetic field. • The study of fine and hyperfine structure of one and two electron atmos. • Elementary idea about rotation and vibration and solution of nuclear equation. • Study the application of group theory associated with molecular symmetry. • Introduction to LASER and its applications.	
Pre-requisite:	Elementary idea of Quantum Physics and structure of atoms	
UNIT	**CONTENT**	**HOURS**
I	One Electron Atom, Introduction to Quantum States; Atomic orbital, Parity of the wave function, Angular and radial distribution functions, Many electron atom,Independent particle model, He atom as an example of central field approximation, Central field approximation for many electron atom, Slater determinant, L-S and j-j coupling, Equivalent and nonequivalent electrons, Energy levels and spectra, Spectroscopic terms, Hunds rule, Lande interval rule, Alkali spectra.	8
II	Interaction of radiation with matter, Time dependent perturbation, Sinusoidal or constant perturbation, Application of the general equations, Sinusoidal perturbation, Interaction of an atom with electromagnetic wave, Hamiltonian Selection rules, Non resonant excitation, Comparison with the elastically bound electron model, Resonant excitation, Induced absorption and emission.	8
III	Solution of Dirac equation in a central field, Relativistic correction to the energy of one electron atom, Fine structure of spectral lines, Selection rules, Lamb shift, Effect of external magnetic field, Hyperfine interaction and isotope shift, Hyperfine splitting of spectral lines, Molecular Electronic States, Concept of molecular potential, Separation of electronic and nuclear wavefunctions, Born-Oppenheimer approximation, Electronic states of diatomic molecules, Electronic angular momenta, Wavefunction, The LCAO approach, States for hydrogen molecular ion, Exchange and Overlap integral.	16
IV	Rotation and Vibration of MoleculesSolution of nuclear equation, Non-rigid rotator, Centrifugal distortion, Symmetric top molecules, Harmonic oscillator and the anharmonic oscillatorapproximation, Morse potential, Spectra of Diatomic Molecules Transition matrix elements, Vibration rotation spectra, Pure vibrational and rotational transitions, Electronic transitions, Franck Condon principle, Rotational structure of electronic transitions, Fortrat diagram, Dissociation energy of molecules, Continuous spectra, Raman transitions and Raman spectra.	14
V	Basic elements of a laser, Threshold condition, Fourlevel laser system, CW operation of laser, Critical pumping rate, Population inversion and photon number in the cavity around threshold, Output coupling of laser power, Optical resonators, Cavity modes, Mode selection, Pulsed operation of laser, Q-switching and Mode locking, Experimental technique of Q-switching and mode locking Different laser systems, Ruby, Co_2, Dye and Semiconductor diode laser.	14
Course Outcomes as per Bloom's Taxonomy		
CO1	Students will be able to **recall**[1] the concept of quantum states for one and many electron system.	
CO2	They will be able to **apply**[3] of time dependent perturbation theory in real world problems in Physics.	
CO3	They will be able to **solve**[3] of Dirac equation in a central field.	
CO4	They will be able to **make use of**[3] group theory in the analysis of vibration of Polyatomic Molecules.	
CO5	They will be able to **understand**[1] about the Einstein's coefficients and relating them to LASERs.	

Text Books:	• B. H. Bransden and C. J. Jochain, Physics of Atoms and Molecules, 2nd Edition, Pearson Publishers, 2003. • J. M. Hollas, Basic Atomic and Molecular Spectroscopy, 4th Edition, Royal Society of Chemistry, 2002. • R. Kumar, Atomic and Molecular Physics, Campus book international, 2013.
Reference Books:	• G. Herzberg, Molecular Spectra and Molecular Structure, Spectra of Diatomic Molecules, 2nd Edition, Krieger Pub Co., 1989. • W. Demtroder, Laser Spectroscopy: Basic Concepts and Instrumentations, 3rd Edition, Springer Publishers, 2002. • W. Demtroder, Atoms, Molecules and Photons: An Introduction to Atomic-, Molecular- and Quantum Physics, 3rd Edition, Springer Publishers, 2019.

Discipline Specific Electives II

COURSE CODE	COMMUNICATION ELECTRONICS	Total Lec.: 45
PY20M205		**3-0-0**
Learning Objectives:	• To understand the basic components of signal transmission • To acquire the knowledge about the characteristics and applications of Microwaves in communication technology • To understand the transmission and antenna based mechanism involved in communication • To learn the reliability parameters which are involved in communication and signal processing.	
Pre-requisite:	Elementary idea of electronic circuit, propagation waves and related phenomena	
UNIT	**CONTENT**	**HOURS**
I	Amplitude modulation, Current collector modulation , Square law modulation, Suppressed carrier balance modulator, Study of amplitude modulated transmission, Square law detector, Distortion in linear diode detector.	9
II	Microwave Electronics, Characteristics feature of microwave Application of microwave, Generation of microwave by tubes, Limitation of conventional tubes, Klystron, Reflex Klystron, Magnetron, Travelling wave tube.	9
III	Definition of microwave, Microwave powermeasurement, Impedance measurement, Frequency measurement, VSWR measurement in wave guide, Isolator, Modulator. Directional Coupler, Magic tree.	9
IV	Voltage and Current equation for transmission lines, Reflection and transmission coefficient, Standing wave and standing wave ratio, Impedance matching.	9
V	Radiation Mechanism, Elementary doublet, Current and Voltage antennas, Resonant/Non Resonant Antennas, Antenna Gain, Beam width, Polarization, Directivity, Radiation Resistance, Self and mutual Impedance, Dipole array, Hog Antenna.	9
Course Outcomes as per Bloom's Taxonomy		
CO1	Students will be able to **identify**[1] the main components of signal processing and communication electronics.	
CO2	They will be able to **understand**[2] the characteristic features of communication waves and their applications.	
CO3	They will be able to **determine**[3] the important factors and equipments involved in communication system.	
CO4	They will be able to **evaluate**[5]the significant parameters which makes the basic architecture of transmission.	
CO5	They will be able to develop an **understanding**[2]about antenna in communication electronics, its importance and the key factors responsible for signal processing.	
Text Books:	• K.C. Gupta, Microwaves, John Wiley and Sons, 1980. • G. Kennedy, B. Davis, and S. Prasanna, Kennedy's Electronic Communication Systems, 6th Edition, Mc-graw Hill Publications, 2017. • S. Haykin, and M. Moher, Communication Systems, 5th Edition, Wiley Student Edition, Wiley Publications, 2009.	
Reference Books:	• S.Y. Liao, Microwave Devices and Circuits, 3rd Edition, Pearson Education India, 2003. • R.L. Shrader, Electronic Communication, 6th Edition, Mc-graw Hill Publications, 1990. • J.D. Kraus, R.J. Marhefka, and A.S. Khan, Antennas and Wave Propagation, 5th Edition, Mc-graw Hill Publications, 2017.	

Discipline Specific Electives II

COURSE CODE	ASTRONOMY AND ASTROPHYSICS	Total Lec.: 45
PY20M206		**3-0-0**
Learning Objectives:	• To understand Tools of Astronomy and celestial mechanics. • To introduce basic astronomical principles in the study of the planets, stars and galaxies. • To learn the nature of stars and their associated parameters. • To review the various aspects of Galactic Astronomy.	
Pre-requisite:	Knowledge about basic optics and optical instruments, wave propagation, and earth atmosphere.	
UNIT	**CONTENT**	**HOURS**
I	The celestial Sphere, Positions of stars, Proper motions of stars and planets, Distances of nearby stars, Telescopes: Basic Optics, Optical Telescopes, Radio Telescopes, Infrared, Ultraviolet, X-ray, and Gamma Ray Astronomy detectors and observatories, Gravitational Waves detectors and Neutrino detectors, All Sky Surveys and Virtual Observatories.	10
II	The Sun, The Physical Processes in the solar system, The Terrestrial and the Giant Planets, Formation of Planetary Systems, The brightness of the stars, Color magnitude diagrams, The luminosities of the stars, Angular radii of stars, Effective temperatures of stars, Masses and radii of stars, Binary stars, Search for Extrasolar Planets.	10
III	Spectral classification, Understanding stellar spectra, Population II stars, Stellar rotation, Stellar magnetic fields, Stars with peculiar spectra, Pulsating stars, Explosive stars, Interstellar absorption.	7
IV	The shape and size of our Galaxy, Interstellar extinction and reddening, Galactic coordinates, Galactic rotation, Stellar population, Inter Stellar Medium, The galactic magnetic field and Cosmic rays.	8
V	Normal galaxies, Morphological classification and kinematics, Expansion of the Universe, Active galaxies, Clusters of galaxies, Large scale distribution of galaxies, Gamma ray bursts.	10
	Course Outcomes as per Bloom's Taxonomy	
CO1	Students will be able to **define**[1] and have knowledge of the expansion of the universe and the nature of the planets, stars and galaxies.	
CO2	They will be able to **understanding**[2] how the astronomical observations are done for these celestial objects.	
CO3	They will be able to **applying**[3] Mathematical tools and Physics laws to understand the nature of planets, stars and galaxies.	
CO4	They will be able to use online resources to **analyze**[4]the data obtained from various Astronomical observations.	
CO5	They will be able to **evaluate**[5] the results of this analysis and interpret the nature of the Solar system, variety of stars and galaxies.	
Text Books:	• E. BohmVitense, Introduction to Stellar Astrophysics, Volume 1, Basic stellar observations and data, Cambridge University Press, 1989. • K.D. Abhayankar, Astrophysics: Stars and Galaxies, Universities Press, 2001. • B.Basu, T. Chattopadhyay, and S.N. Biswas, An Introduction to Astrophysics, 2nd Edition, Prentice Hall India Learning Private Limited, 2010.	
Reference Books:	• B.W. Carroll, D.A. Ostlie, An Introduction to Modern Astrophysics, 2nd Edition, Pearson Addison-Wesley, 2007. • A.R. Choudhuri, Astrophysics for Physicists, Cambridge University Press, 2010. • D. Mihalas and J. J. Binney, Galactic Astronomy: Structure and Kinematics, 2nd Revised Edition, W.H. Freeman & Co Ltd, 1981.	

Practical

COURSE CODE	PRACTICE LAB III	Practical: 60
PY20M207		2
	1. To construct A/D to D/A convertors. 2. To design and study oscillators. 3. To design and study triangular wave generator. 4. To study multivibrator. 5. Studying Op-amps and its application. 6. To study JK Flip-Flop and up-down counter. 7. To study active and passive filter. 8. To study FET – biasing, characteristic, and application as amplifier. 9. To study MOSFET – biasing, characteristic, and application as amplifier. 10. To study UJT –characteristic, and its application as and relaxation oscillator.	

COURSE CODE	PRACTICE LAB IV	Practical: 60
PY20M208		2
	1. To produce and measure the low pressure, and high pressure. 2. To study the nuclear magnetic resonance (NMR). 3. To measure the lifetime of minority carriers in semiconductor using Haynes–Shockley experiment. 4. Measuring the lattice parameter and indexing of powder photograph. 5. Rotation/Oscillation photograph and their interpretation. 6. To study the ferroelectric transition in TGS crystal and measurement of Curie temperature. 7. To Determine the transition temperature in high Tc superconductors. 8. To measure thermoelectric power. 9. To study crystal structure using x ray diffraction powder photograph method. 10. To fabricate the carbon nano-tube by Spray Pysolysis method and verify through x-ray diffraction.	

Project Based Learning II

<table>
<tr><td>COURSE CODE</td><td>PROJECT BASED LEARNING</td></tr>
<tr><td>PB20B201</td><td></td></tr>
<tr><td>Learning Objectives:</td><td>• Integrating the knowledge and skills of various courses on the basis of multidisciplinary projects.
• Develop the skill of critical thinking and evaluation.
• To develop 21st century success skills such as critical thinking, problem solving, communication, collaboration and creativity/innovation among the students.
• To enhance deep understanding of academic, personal and social development in students.
• Employ the specialized vocabularies and methodologies.</td></tr>
<tr><td>General Guidelines:</td><td>• PBL will be an integral part of UG/PG Programs at different levels.
• Each semester offering PBL will provide a separate Course Code, two credits will be allotted to it.
• Faculty will be assigned as mentor to a group of 30 students minimum by HoS.
• Faculty mentor will have 4 hours/week to conduct PBL for assigned students.
• Student will select a topic of their choice from syllabus of any course offered in respectiveSemester (in-lines with sustainable development goals).
• Student may work as a team maximum 3 or minimum 2 members for single topic.
• For MSE, student's performance will be assessed by panel of 2 experts either from other Department/school, or from same department/school based on chosen topic. This will becomprised of a presentation by student followed by viva-voce. It will be evaluated for 30 marks.
• 20 marks would be allotted for continuous performance assessment by concerned guide/mentor.
• For ESE, student will need to submit a project report in prescribed format, duly signed by concerned guide/mentor and head of the school. The report should be comprised of followingcomponents:
1. Introduction
2. Review of literature
3. Methodology
4. Result and Discussion
5. Conclusion and Project Outcomes
6. References
• In ESE, viva-voce of students will be conducted on the basis of report, by one external and one internal faculty which is of 50 Marks.
Student will need to submit three copies for
1. Concerned School
2. Central Library
3. Self.
The integrity of the report should be maintained by student. Any malpractice will not be entertained.
• Writing Ethics to be followed by student, a limit of 10 % plagiarism is permissible. Plagiarism report is to be attached along with the report.
• Project could be a case study/ analytical work /field work/ experimental work/ programming or as per the suitability of the program.</td></tr>
</table>

Syllabus

SEMESTER III

Core Course-I

COURSE CODE	NUCLEAR AND PARTICLE PHYSICS	Total Lec.: 60
PY20M301		4-0-0
Learning Objectives:	• Basic nuclear physics properties and nuclear models for understanding of related reaction dynamics. • To learn about the decay phenomenon and the process how they will occur. • Knowledge of various model compare to nucleus. • Knowledge of scattering process.	
Pre-requisite:	Elementary idea of Quantum Physics and Statistical Mechanics	
UNIT	**CONTENT**	**HOURS**
I	Structure of nucleus - Thomson model, Rutherford model, proton-electron model, proton-neutron hypothesis; properties of nucleus - mass, radius, density, nuclear angular momentum, magnetic moment, electric quadrupole moment, wave mechanical properties – BE and FD statistics, parity; atomic mass, nuclear stability, nuclear forces (Meson theory), isotopes, isotones, isobars, isomers, magic number and mirror nuclei. Liquid drop model, semi empirical mass formula (Weizacker's semi-empirical formula), shell model.	12
II	Nuclear Reactions: $E = mc^2$, mass defect, binding energy and Q value, transmutation, nuclear energy, nuclear fission, nuclear reactors, types of nuclear reactors, Breeder reactors, nuclear fusion, nuclear fusion in stars, nuclear fusion reactors	12
III	Radioactivity and Interaction of Nuclear Radiation with Matter: α-, β-, and γ- rays and their properties; rate of energy loss, Bethe-Bloch formula, absorption of γ-rays in matter, linear and mass absorption coefficient, annihilation of electron-positron pair, Compton effect.	12
IV	Detectors for Nuclear Particles: Interaction between particles and matter, ionization counter, Geiger-Muller counter, scintillation counter, solid state or semiconductor detectors, Compton suppressed germanium detectors, Cloud and Bubble chambers, Spark chambers.	12
V	Cosmic Rays and Elementary Particles: Introduction, primary and secondary cosmic rays, altitude effect, latitude effect, East-West effect, cosmic ray shower; classification of elementary particles (gravitons, photons, leptons, hadrons etc.), quarks, antiparticle.	12
	Course Outcomes as per Bloom's Taxonomy	
CO1	Students will be able to **recall[1]** the concept of various properties of a nucleus and models, alpha, beta, and gamma rays, nuclear detectors.	
CO2	They will be able to **apply[3]** mass defect, mass-energy relation in nuclear reactions and radiation reaction with matter	
CO3	They will be able to **solve[3]** for Q value of a nuclear reaction and balance nculae reactions.	
CO4	They will be able to **make use of[3]** elementary particles in understanding nuclear reactions.	
CO5	They will be able to **understand[1]** Cosmic shower, elementary particles.	
Text Books:	• W.E. Burcham& M. Jobes, Nuclear & Particle Physics, Prentice Hall, 1994. • K.S. Krane, Introductory Nuclear Physics, Wiley, 2008. • V. Devnathan ,Nuclear Physics, 2nd Edition, Alpha Science International Ltd, 2011. • B.L. Cohen, Concepts of Nuclear Physics, 1st Edition, McGraw Hill Education, 2017. • B.B. Srivastava, Fundamentals of Nuclear Physics, Rastogi Publications, 2005. • S.N. Ghoshal, Nuclear Physics, S. Chand & Company, 2008.	

Reference Books:	• F. Close, Particle Physics: A Very Short Introduction, 1st Edition, OUP UK, 2004 • S.S.M. Wong, Introductory Nuclear Physics, 2nd Edition, , Wiley-VCH, 1998. • B.R. Martin, Nuclear & Particle Physics: An Introduction, 2nd Edition, Wiley–Blackwell, 2009,. • J. Lilley, Nuclear Physics – Principles & Applications, Wiley-India, 2006. • D. Griffiths,Introduction to Elementary Particles, Wiley-VCH, 2008.

Core Course-II

COURSE CODE	DIGITAL CIRCUITS AND DESIGN		Total Lec.: 60
PY20M302			4-0-0
Learning Objectives:	• To acquire knowledge about number systems and their conversion among different number systems • To acquire the basic knowledge of digital logic levels and Boolean algebra • Develop better understand about digital electronics circuits. • To prepare students to perform the analysis and design of various digital electronic circuits.		
Pre-requisite:	Elementary idea of electronics.		
UNIT	CONTENT		HOURS
I	Number Systems: Positional number system, binary representation, 2's complement notation, binary addition and subtraction, octal number system, hexadecimal system,1's complement, 2's complement, binary-to- decimal conversion, octal-to-decimal conversion, hexadecimal-to-decimal conversion, binary-octal and binary-hex conversions, hex-octal and octal-hex conversions, binary codes – BCD, Unicode, and ASCII codes, BCD-to-binary conversion, binary-to-BCD conversion; gray code – binary-gray code conversion, gray code-binary conversion; error detection and correction codes – parity code, repetition code, hamming code; binary multiplication, binary division, BCD addition and subtraction.		12
II	Boolean Algebra: Switching circuits, AND, OR, NOT, Exclusive OR, NAND, NR, Exclusive NOR gates, universal gates, Schmitt gates, fan-out of logic gates, buffer and transceivers, truth table, Boolean functions, postulates and theorems of Boolean algebra, duality principle, Venn diagram, canonical forms of Boolean functions, simplification of Boolean functions, sum of product (SOP) and product of sum (POS) representations, Karnaugh maps (construction of a Karnnaugh map), incompletely specified functions, don't cares.		16
III	Combinational and Sequential Circuits: Logic gates, NAND and NOR as universal gates, realization of logical functions using SOP and POS techniques, XOR gate, decoders, encoders, multiplexers, de-multiplexers, code conversion using logic gates and MSI ICs, half adder, full adder, serial adder, half subtractor, full subtractor, digital comparator, Transistor Transistor Logic (TTL) – standard TTL, low-power TTL, high-power TTL, Schottky TTL; emitted coupled logic; CMOS; CMOS-to-TTL Interface, TTL-to-CMOS interface; classification of digital ICs.		14
IV	Multiplexers and Demultiplexers: Multiplexer - Inside the multiplexer, implementing Boolean functions with multiplexers, multiplexers for parallel-to-serial data conversion, cascading multiplexer circuits; Encoders; Demultiplexer and decoders. Information Registers: Flip-flops - J-K, S-R, clocked, master-slave, & edge-triggered flip-flops, synchronizer; timer, counter, shift register, bistablemultivibrator, Schmitt trigger, monostablemultivibrator, digital IC based monostablemultivibrator, IC timer based multivibrator.		10
V	Visual Displays: Single-element displays, seven-segment displays. Memory Circuits: Read only memories, shift-register memories, Random-Access Memories.		8
Course Outcomes as per Bloom's Taxonomy			
CO1	Students will be able to **Recall**[1] the concept of various concepts of digital electronics, number system, digital gates, flip-flops.		
CO2	They will be able to **apply**[3]the concept of digital electronics in various digital gates, flip-flops, timer, counter.		
CO3	They will be able to **solve**[3]various problems – input/output, gates formation, timer, and counter.		
CO4	They will be able to **make use of**[3] digital electronics toset-up physics (e.g., optics, atomic,		

	molecular, and nuclear) experiments and interface.
CO5	They will be able to **understand**[1] basics of number systems, AND, NAND, OR, XOR gates, various flip-flops.
Text Books:	• R. L. Boylestad& L. Nashelsky, Electronic Devices & Circuit Theory, Pearson, 2015. • D.L. Eggleston, Basic Electronics for Scientists and Engineers, Cambridge University Press, 2011. • S.K. Mandal,Digital Electronics and Logic Design, 1st Edition, McGraw Hill Education, 2019. • D. Chattopadhyay& P.C. Rakshit, Electronics Principle and Applications, 6th Edition, New Age International Private Limited, 2020. • C.K. Alexander & M.N.O. Sadiku, Fundamentals of Electric Circuits, 5th Edition, McGraw Hill Education, 2013. • Malvino and Leech, Digital Principles and Applications, 5th Edition, McGraw-Hill Education, 1994. • S. Agrawal& S. Singh, Analog & Digital Electronics, Wiley, 2019.
Reference Books:	• Gupta and Kumar, Handbook of Electronics, Pragati Edition, 2020. • V.K. Mehta, Principles of Electronics, 7th Revised Edition, S Chand, 2014. • E.D. Gates, Introduction to Electronics, 6th Edition, Cengage, 2009.

Core Course-III

COURSE CODE	**PLASMA PHYSICS**	**Total Lec.: 60**
PY20M303		**4-0-0**

Learning Objectives:	• The course provides an introduction to plasma physics, and its application • Developing a physical understanding for the characteristic properties of plasmas, including how they can be created and where they appear. • Provide knowledge about theory of Magnetohydrodynamics (MHD). • Knowledge about types of plasma and process of collision in it.	
Pre-requisite:	Elementary idea of electrostatics, magnetostatics, waves, and oscillations.	
UNIT	**CONTENT**	**HOURS**
I	Introduction to Plasma:What is plasma, how are plasma made, what are plasmas used for, Debye shielding. Motion of Particle in Electric and Magnetic Fields:Gyro-motion, uniform electric and magnetic field, E x B drift, particle motion in non-uniform magnetic fields – curvature drift, magnetic mirror.	10
II	Particle Drift in Time Dependent Field: Time varying B and E fields, adiabatic compression, J conservation, concept of mapping (brief idea-qualitative). Fluid Equation for a Plasma: Continuity equation, momentum balance equation, equation of state, two-fluid equation, plasma resistivity, diamagnetic drift.	16
III	Magnetohydrodynamics: The magnetohydrodynamics equation, quasi-neutrality approximation, 'small Larmour approximation', approximation of 'infinite conductivity', conservation of magnetic flux, conservation of energy, magnetic Reynolds number, magnetohydrodynamics equilibrium equation, magnetic pressure – the concept of beta, concept of tokamak. Ionized Plasma and Collision in Plasmas: Degree of ionization of plasma, collision cross cross-section, mean-free path, penetration of neutrals into plasma, Coulomb collision, plasma resistivity, energy transfer, brief idea of diffusion as a random walk (qualitative).	16
IV	Fokker-Planck Equation: The Fokker-Planck equation-general form, Fokker-Planck equation for electron-ion collisions, 'Lorentz gas' approximation. Waves in Plasma: Concepts of wave propagation in unmagnetized and magnetized plasma, group velocity, Langmuir waves, ion sound waves, Alfven waves, magnetosonic waves (brief discussion).	10
V	Instabilities: Concept of Rayleigh-Taylor instability, flute instability, plane plasma slab. Vlasov Equation and Landau's Treatment: Need for a kinetic theory, particle distribution function, Concept of Boltzmann-Vlasov equation, Vlasov-Maxwell equation, and Landau's treatment.	8
	Course Outcomes as per Bloom's Taxonomy	
CO1	Students will be able to **recall**[1] the concept of plasma physics, its applications, motion of charged particle in electric and magnetic fields.	
CO2	They will be able to **apply**[3]the concept of Larmour approximation, Fokker-Planck equation, Vlasov equation.	
CO3	They will be able to **solve**[3]wave propagation in plasma, collisions in plasma, instabilities in plasma.	
CO4	They will be able to **make use of**[3] various plasma theories to solve magnetohydrodynamics problems.	
CO5	They will be able to **understand**[1] basics of plasma equation, energy transfer, momentum transfer, wave propagation, Vlasov equation, Landau's idea, Rayleigh-Taylor instability.	
Text Books:	• Robert J Goldston& Paul H Rutherford, Introduction to Plasma Physics, Imprint: New York: Taylor & Francis, 2000. • Paul M. Bellan, Fundamentals of Plasma Physics, Cambridge University Press, 2006. • A. Bittencourt, Plasma Physics, 3rd Edition, Springer-Verlag New York Inc, 2004. • S.N. Goswami, Elements of Plasma Physics, New Central Book Agency, 2011.	

Reference Books:	• F.E. Chen, Introduction to Plasma Physics, 4th Edition, Springer, 2012. • S. Eliezer& Y. Eliezer, The Fourth State of Matter: An Introduction to Plasma Physics,Institute of Physics Publishing; 2nd edition, June 2001. • R.M. Kulsrud, Plasma Physics for Astrophysics, New Age Int. Pvt. Ltd, 2010.

Core Course-IV

COURSE CODE	**QUANTUM FIELD THEORY**	**Total Lec.: 60**

PY20M304		4-0-0
Learning Objectives:	• To introduce the basic ideas of quantum field theory; • To understand how quantum mechanics and special relativity • to develop techniques to at least the level of tree-level Feynman rules for quantum electrodynamics; • to provide the foundation for more advanced studies in quantum field theory.	
Pre-requisite:	Quantum mechanics.	
UNIT	**CONTENT**	**HOURS**
I	Relativistic Quantum Mechanics: Introduction, Klein-Gordon equation, Dirac equation, probability and current densities, covariance of Dirac equation, plane wave solution, electron in an electromagnetic field, hole theory and positrons. Physics and Special Relativity: Introduction -Why quantum field theory?, Special relativity, quick review of particle physics, elementary particles, Higgs mechanism, grand unification, supersymmetry, string theory. Lagrangian Field Theory: Basic Lagrangian mechanics, action & equations of motion, canonical momentum & Hamiltonian, Lagrangian field theory, symmetries & conservation laws, conserved currents, electromagnetic field, Gauge transformations.	16
II	The Dirac Equation: Classical Dirac field, adding quantum theory, form of Dirac matrices, properties of Dirac matrices, adjointspinors& transformation properties, slash notation, solutions of Dirac equation, free space solutions, boosts, rotations, &helicity, Weylspinors. Scalar Fields: Arriving at the Klien-Gordon equation, reinterpreting the field, field quantization of scalar field, states in quantum field theory, positive & negative frequency, number operators, normalization of the states, Bose-Einstein statistics, normal & time-ordered products, complex scalar field. Feynman Rules: Interaction picture, perturbation theory, basics of Feynman rules, calculating amplitudes, steps to construct amplitude, rates of decay & lifetimes.	16
III	Quantum Electrodynamics: Review of classical electrodynamics, quantized electromagnetic field, Gauge invariance & QED, Feynman rules for QED. Spontaneous Symmetry Breaking and Higgs Mechanism: Symmetry breaking in field theory, mass terms in the Lagrangian, aside on units, spontaneous symmetry breaking and mass, Lagrangian with multiple particles, Higgs mechanism.	10
IV	Electroweak Theory: Right- & left-handed spinors, mass less Dirac Lagrangian, Leptonic fields of the electroweak interaction, unitary transformations & Gauge fields of the theory, weak mixing or Weinberg angle, symmetry breaking, giving mass to the Lepton fields, Gauge masses. Path Integrals: Gaussian and basic path integrals.	10
V	Supersymmetry: Basic overview of supersymmetry, supercharge, supersymmetric quantum mechanics, simplified Wess-Zumino model, simple SUSY Lagrangian.	8
	Course Outcomes as per Bloom's Taxonomy	
CO1	Students will be able to **recall**[1] the concept of quantum mechanics, electromagnetic theory, Lagrangian and Hamiltonian formulation, scalar and vector fields	
CO2	They will be able to **apply**[3]the concept of Feynmann rules	
CO3	They will be able to **solve**[3]symmetry breaking, path integrals using the concepts.	
CO4	They will be able to **make use of**[3] Gaussian and basic path integrals and Feynmamm rules	
CO5	They will be able to **understand**[1] basics of relativistic quantum mechanics, Feynmann rules, path integrals, and symmetry breaking, and supersymmetry.	

Text Books:	• M. Peskin and D. Schroeder, An Introduction to Quantum Field Theory, 1st edition, Westview Press, 1995,. • S. Weinberg, The Quantum Theory of Fields, Cambridge University Press, 2005. • M. Srednicki, Quantum Field Theory, 2nd edition, Cambridge University Press, 1996. • M.E. Peskin& D.V. Schroeder, An Introduction to Quantum Field Theory, CRC Press, 2018.
Reference Books:	• A. Zee, Quantum Field Theory in a Nutshell, 2nd edition, Princeton University Press, 2010. • T. Banks,Modern Quantum Field Theory: A Concise Introduction,1st edition, Cambridge University Press, 2008.

Discipline Specific Elective - III

COURSE CODE	Digital Circuits And Fundamental of Microprocessor	Total Lec.: 45
PY20M305		3-0-0
Learning Objectives:	• To learn the basic methods for the design of digital circuits • Knowledge about fundamental concepts used in the design of digital systems. • Knowledge about construction and working of microprocessor • To understand concepts of concept of digital communication • Concept of pulse modulation and its application	
Pre-requisite:	Elementary idea of digital electronics	
UNIT	CONTENT	HOURS
I	**Analog/Digital Conversion:** Introduction to A/D conversion, digital-to-analog (DAC) converter, time-domain (averaging) DAC, multiplying DACs, choosing a DAC, analog-to-digital (ADC) converter, some useful A/D and D/A converters, choosing an ADC, 16-channel A/D data-acquisition system, 3½ -digit voltmeter, D/A converter specifications – resolution, accuracy, conversion speed/setting tie, dynamic range; A/D converter specifications – resolution, accuracy, gain & offset errors, gain & offset drifts, sampling frequency & aliasing phenomenon, quantization error, nonlinearity, differential nonlinearity, conversion time, code width; A/D converter terminology – unipolar mode operation, bipolar mode operation, coding, low byte & high byte, right and left justified data, command register, status register; data acquisition.	11
II	**Microprocessor:** Introduction, evolution of microprocessor, inside a microprocessor – arithmetic logic unit, register file, control unit; 4-Bit, 8-Bit, 16-Bit, & 32-Bit systems, description of 8085 microprocessor, Pentium series microprocessor (brief description); brief description of peripherial devices – programmable timer/counter, programmable peripherial interface, programmable interrupt controller, math processor, floppy disk controller. Microcontroller: Introduction, inside the microcontroller – central processing unit (CPU), random success memory (RAM), read only memory (ROM); microcontroller architecture, power saving modes, a few applications (eight-bit 7 16-bit microcontrollers).	10
III	**Digital Data Communication Standards:** Serial communications: RS232, handshaking, implementation of RS232 on PC; Universal Serial Bus (USB) - USB standards, types and elements of USB transfers.	8
IV	**Parallel Communications:** General Purpose Interface Bus (GPIB), GPIB signals and lines, handshaking and interface management, implementation of a GPIB on a PC; Basic idea of sending data through a COM port.	8
V	**Digital Pulse Modulation:** Need for digital transmission, pulse code modulation,digital carrier modulation techniques, sampling, quantization and encoding; concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK); comparison with analog pulse modulation.	8
	Course Outcomes as per Bloom's Taxonomy	
CO1	Students will be able to **recall**[1] the concept of various concepts of digital electronics, number system, digital gates, flip-flops.	
CO2	They will be able to **apply**[3]the concept of digital electronics in DAC/ADC and DAQ/PC interface and Digital communications and data transmission.	
CO3	They will be able to **solve**[3]Trouble-shoot complicated experimental set-up, design digital circuits for research in applied physics & technology	
CO4	They will be able to **make use of**[3] digital electronics toset-up complex physics (e.g., optics, atomic, molecular, and nuclear) experiments requiring high-end and expansive electronic components/devices	
CO5	They will be able to **understand**[1] basics of IC and digital circuits, and difference between analog and digital circuits.	

Text Books:	• R. L. Boylestad& L. Nashelsky, Electronic Devices & Circuit Theory, 2015, Pearson. • D.L. Eggleston, Basic Electronics for Scientists and Engineers,2011, Cambridge University Press. • D. Chattopadhyay& P.C. Rakshit, Electronics Principle and Applications,2020, New Age International Publication. • C.K. Alexander & M.N.O. Sadiku, Fundamentals of Electric Circuits, 5^{th} Edition, 2013,McGraw Hill Education. • T.R. Vishwanathan, G.K. Mehta, & V. Rajaraman,Electronics for Scientists & Engineers, Prentice-Hall of India, 1978.
Reference Books:	• Gupta and Kumar, Handbook of Electronics, 2016, PRAGATI PRAKASHAN. • V.K. Mehta, Principles of Electronics, 7^{th}Revised edition, 2014, S Chand. • D. Barnaal, Analog Electronics for Scientists, 1^{st} edition, 1989, Waveland Press, Inc. • E.D. Gates, Introduction to Electronics, 6^{th} edition,2011, Cengage Learning, Inc. • S. Agrawal& S. Singh, Analog & Digital Electronics, 2019, Wiley.

Discipline Specific Elective - III

COURSE CODE	GROUP THEORY FOR PHYISCS	Total Lec.: 45
PY20M306		**3-0-0**
Learning Objectives:	• Concept of group theory. • To obtain proficiency in the study of symmetries of physical systems • Application of group theory in crystallography and solid state physics, angular momentum, and quantum mechanics. • Concept of groups to classify and quantify natural phenomenon.	
Pre-requisite:	Quantum mechanics, solid state physics.	
UNIT	**CONTENT**	**HOURS**
I	Abstract Group Theory: Definition and nomenclature, rearrangement theorem, cyclic group, subgroups and cosets, groups of finite order, conjugate eelments and class structure, normal divisior and factor groups, class multiplication.	10
II	Theory of Group Presentation: Definition, orthogonality theorem, character of a representation, construction of character tables, reducible representation, Abelian group, irreducible representation, direct-product group.	10
III	Full Rotation Group and Angular Momentum: Rotational transformation properties and angular momentum, continuous groups, homomophism, unitary group, Clebsch-Gordon coefficients, rotation representation matrix, vector model for addition of angular momenta, Wigner-Eckart theorem.	9
IV	Group Theory, Crystallography, and Solid State Theory: Crystal-symmetry operators, crystallographic point groups, irreducible representation of the point group, symmetry properties in solids, reciprocal lattice and Brillouin zones, energy-band wave-functions.	9
V	Group Theory and Quantum Mechanics: Hamiltonian, approximate eigenfunctions,Hartree-Fock equation, *L-S* term energies, eigenfunction and angular-momentum operators, Born-Oppenheimer approximation.	7
Course Outcomes as per Bloom's Taxonomy		
CO1	Students will be able to **recall**[1] the concept of various types of group and their representations.	
CO2	They will be able to **apply**[3]the concept in angular momentum, crystallography, and quantum mechanics.	
CO3	They will be able to **solve**[3]physics problems using group theory.	
CO4	They will be able to **make use of**[3] group theory to understand advanced level physics,	
CO5	They will be able to **understand**[1] how group theory can be implemented in various branched of physics.	
Text Books:	• A.W. Joshi, Elements of Group Theory for Physicists, 5th Edition, New Age International, 2018. • M. Tinkham, Group Theory & Quantum Mechanics, Dover Publications Inc, 2003. • P. Ramadevi& V. Dubey, Group Theory for Physicists with Application, Cambridge University Press, 2021.	
Reference Books:	• H.K. Dass& R. Verma, Mathematical Physics, S Chand Publishing, 2018. • J.F. Cornwell, Group Theory in Physics, Academic Press; Abridged edition, 1997. • W.K. Tung, Group Theory in Physics, World Scientific Publishing Co Pte Ltd, 1985. • P.B. Pal, A Physicist's Introduction to Algebraic Structure: Vector Spaces, Groups, Topological Spaces & More, Cambridge University Press, 2021.	

Practical Paper

COURSE CODE	PRACTICE LAB V	Practical: 30
PY20M307		**2**
	1. To study magneticproperties of solids (diamagnetism, paramagnetism, ferromagnetism). 2. To study alpha, beta, and gamma rays and GM counter. 3. To study the Balmer series. 4. To study properties of prism and grating. 5. To study interference and diffraction of laser using various apertures. 6. To study Half Adder, Full Adder, Half Subtractor, Full Subtractor, coder, decoder, multiplexer and microprocessor. 7. To study B-H loop. 8. To study friction (static & dynamic). 9. To study projectile motion. 10. To study spring-mass oscillation. 11. To study Planck's constant. 12. To study surface tension. 13. To study viscosity. 14. To study Biot-Savart law. 15. To study Faraday's law. 16. To study arbitrary waveform generator and DSO using NILabVIEW. 17. Analysis of experimental data using Origin software.	

Project Based Learning III

<table>
<tr><td>COURSE CODE</td><td>PROJECT BASED LEARNING</td></tr>
<tr><td>PB20B301</td><td></td></tr>
<tr><td>Learning Objectives:</td><td>

Integrating the knowledge and skills of various courses on the basis of multidisciplinary projects.
Develop the skill of critical thinking and evaluation.
To develop 21st century success skills such as critical thinking, problem solving, communication, collaboration and creativity/innovation among the students.
To enhance deep understanding of academic, personal and social development in students.
Employ the specialized vocabularies and methodologies.
</td></tr>
<tr><td>General Guidelines:</td><td>

PBL will be an integral part of UG/PG Programs at different levels.
Each semester offering PBL will provide a separate Course Code, two credits will be allotted to it.
Faculty will be assigned as mentor to a group of 30 students minimum by HoS.
Faculty mentor will have 4 hours/week to conduct PBL for assigned students.
Student will select a topic of their choice from syllabus of any course offered in respectiveSemester (in-lines with sustainable development goals).
Student may work as a team maximum 3 or minimum 2 members for single topic.
For MSE, student's performance will be assessed by panel of 2 experts either from other Department/school, or from same department/school based on chosen topic. This will becomprised of a presentation by student followed by viva-voce. It will be evaluated for 30 marks.
20 marks would be allotted for continuous performance assessment by concerned guide/mentor.
For ESE, student will need to submit a project report in prescribed format, duly signed by concerned guide/mentor and head of the school. The report should be comprised of followingcomponents:
1. Introduction
2. Review of literature
3. Methodology
4. Result and Discussion
5. Conclusion and Project Outcomes
6. References
In ESE, viva-voce of students will be conducted on the basis of report, by one external and one internal faculty which is of 50 Marks.
Student will need to submit three copies for
1. Concerned School
2. Central Library
3. Self.
The integrity of the report should be maintained by student. Any malpractice will not be entertained.
Writing Ethics to be followed by student, a limit of 10 % plagiarism is permissible. Plagiarism report is to be attached along with the report.
Project could be a case study/ analytical work /field work/ experimental work/ programming or as per the suitability of the program.
</td></tr>
</table>

Syllabus

SEMESTER IV

Discipline Specific Electives - IV

COURSE CODE	GENERAL THEORY OF RELATIVITY AND COSMOLOGY	Total Lec.: 45
PY20M401		3-0-0
Learning Objectives:	• Concept of special and general theory of Relativity • Understanding why general relativity is the natural framework for the study of our universe as a physical system. • Formation of stars and their constellations • Knowledge about Big-Bang theory and idea of dark matter	
Pre-requisite:	Elementary idea of mechanics, nuclear physics, reference frames.	
UNIT	**CONTENT**	**HOURS**
I	Special Theory of Relativity: Einstein's postulates of special theory of relativity, Lorentz transformation, time dilation, length contraction, proper length and proper time, simultaneity, twin paradox, invariance of space-time and energy-momentum under Lorentz transformation, relativistic Lagrangian for a free particle,the interdependence of electric and magnetic fields, transformations for E and B, Minkowski's four-dimensional space-time world, Lorentz transformation as rotation in four-space, four-vectors.	12
II	General Theory of Relativity: Equivalence of gravitational and inertial mass, principle of equivalence, Einstein's elevator, gravitational mass of photons, gravitational effect on clock, gravitational red shift, isotropic and homogeneous geometry,	14
III	The Stars:Constellations, stellar population, evolution of stars, cataclysmic events, novae, supernovae, degenerate dwarfs, black holes, gamma-ray bursts,	10
IV	Galaxies and the Universe:Milky way, gaseous nebulae, other galaxies – classification of galaxies, origin and evolution of galaxies, measuring galaxy properties; quite and active galaxies – spectra of active galaxies, types of active galaxies; spatial distribution of galaxies; Hubble's law, observational cosmology, critical mass density of the universe, cosmic inflation, cosmic microwave background, geometry of the universe – flat geometry, spherical geometry, hyperbolic geometry.	12
V	Nuclear Cosmology:The universe today – visible universe, Baryons, cold dark matter, photons, neutrinos, vacuum; expansion of the universe – the scale factor; gravitation and Friedmann equation, high-redshift supernovae and the vacuum energy, reaction rate in the early universe, cosmogenesis, cosmological nucleosynthesis, Big Bang, dark matter, concept of gravitational lensing.	12
	Course Outcomes as per Bloom's Taxonomy	
CO1	Student will be able to **recall**[1] the concept of special theory of relativity, Lorentz transformation, Minkowski space, principle of equivalence, dark matter, various types of stars/galaxies.	
CO2	They will be able to **apply**[3]the concept relativity in galaxy formation, black holes, supernovae.	
CO3	They will be able to **solve**[3]cosmological problems.	
CO4	They will be able to **make use of**[3] the concept of elementary particles in the formation of galaxies and in learning advanced level astronomy/astrophysics.	
CO5	They will be able to **understand**[1] the formation of galaxies, cosmogenesis, Hubble' law, Milky way, big bang theory, and important mathematical quations.	
Text Books:	• M.Roos, Introduction to Cosmology,4th Edition, Wiley, 2015. • A. Liddle,An Introduction to Modern Cosmology, 2nd Edition,Wiley–Blackwell, 2003. • B. Schutz, A First Course in General Relativity, 2nd Edition, Cambridge University Press, 2009. • D. Raine and T. Thomas, An Introduction to the Science of Cosmology, 1st Edition, CRC Press, 2001. • S. Weinberg, Gravitation and cosmology: Principles and applications of the general theory of relativity, 1st Edition, Wiley, 1972. • M.P. Hobson, G.P. Efstathiou, & A.N. Lasenby, General Relativity: An Introduction for Physicists, Cambridge University Press, 2006. • C.G. Boehmer, Introduction to General Relativity & Cosmolog, World Scientific, 2016.	

	• M.K. Sharma & S. Chandra, A Textbook of Astronomy & Astrophysics, Wiley, 2019.
Reference Books:	• J.F. Cornwell, Group Theory in Physics, Academic Press; Abridged edition, 1997. • W.K. Tung, Group Theory in Physics, World Scientific Publishing Co Pte Ltd, 1985.

Discipline Specific Electives - IV

COURSE CODE	Nano science and Nanotechnology	Total Lec.: 45
PY20M402		3-0-0
Learning Objectives:	• To foundational knowledge of the Nanoscience and related fields. • Student will able the difference between nanotechnology and nanoscience. • Gain knowledge about properties of nanostructured materials. • Know about optical and electrical properties of selected nanomaterials. • Will know nanotechnological devices.	
Pre-requisite:	Elementary idea of crystal structure	
UNIT	**CONTENT**	**HOURS**
I	Nanoscale Systems: Length scales in physics, nanostructures – 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods); band structure and density of states of materials at nanoscale, size effects in nano systems, quantum confinement - applications of Schrodinger equation – infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences, Fullerenes, carbon nanotubes (CNT), graphene, gold, silicon, cobalt, silver, zinc oxide, iron oxide etc.	10
II	Synthesis and Characterization of Nanostructure Materials: Top down and Bottom up approach, photolithography. ball milling, gas phase condensation, Physical Vapor Deposition (PVD), thermal evaporation, E-beam evaporation, Pulsed Laser Deposition (PLD), Chemical Vapor Deposition (CVD), Sol-Gel, electro deposition, spray pyrolysis, hydrothermal synthesis, preparation through colloidal methods, Molecular Beam Epitaxy (MBE) growth of quantum dots, X-Ray diffraction, optical microscopy, scanning electron microscopy, atomic force microscopy, scanning tunneling microscopy, Raman spectroscopy, UV-VIS-IR spectroscopy.	12
III	Optical Properties: Coulomb interaction in nanostructures, concept of dielectric constant for nanostructures and charging of nanostructure, quasi-particles and excitons, excitons in direct and indirect band gap semiconductor nanocrystals, quantitative treatment of quasi-particles and excitons, charging effects; radiative processes – absorption, emission, & luminescence; optical properties of heterostructures& nanostructures.	09
IV	Electron Transport: Carrier transport in nanostrcutures, coulomb blockade effect, thermionic emission, tunneling and hoping conductivity; defects and impurities – deep level and surface defects.	07
V	Applications: Quantum dots, nanowires and thin films for photonic devices (LED, solar cells), single electron transfer devices (no derivation), CNT based transistors; nanomaterial devices – quantum dots heterostructure lasers, optical switching and optical data storage; magnetic quantum well; magnetic dots – magnetic data storage.	07
Course Outcomes as per Bloom's Taxonomy		
CO1	Student will **learn^{1}** about the background on Nanoscience	
CO2	Student will able to **understand^{2}** the various methods of nanomaterials synthesis	
CO3	They will be able to **characterise^{4}** nano materials on the basis of their optical properties.	
CO4	They will be able to **Learn^{1}** the advanced concepts in various vapour deposition techniques	
CO5	They will be able to **Apply^{3}** their learned knowledge to develop Nanomaterial's.	
Text Books:	• C. Poole & F. Owners, Introduction to Nanotechnology, Wiley, 2007. • Nalva (Editor), Handbook of Nanostructured Materials and Nanotechnology, 5th Edition, Academic Press, 1999. • S.K. Kulkarni, Nanotechnology: Principles and Practices, 3rd Edition, Springer Nature, 2015. • S. Fiorito, Carbon Nanoutubes, Pan Stanford Publishing Pte Ltd, 2012.	
Reference Books:	• R. Booker & E. Boysen, Nanotechnology, John Wiley & Sons2015. • G. Thomas, Transmission Electron Microscopy of Metals, John Wiley & Sons Inc, 1962.	