Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	B030501T / MT320	**Title of the Course**	Group and Ring Theory & Linear Algebra	**L**	**T**	**P**	**C**
Year	Third	**Semester**	Fifth	**4**	**1**	**0**	**5**
Pre-Requisite	Knowledge of Sets, Relations and Matrices	**Co-requisite**	None				
Course Objectives	The objective of the course is to develop the skills to apply the basic knowledge of Group and Ring theory. The course will further develop understanding the concepts of Linear Algebra and their applications. The topics introduced will serve as basic tools for specialized studies in science field. After successfully completion of course, the student will able to explore subject knowledge into their respective dimensions.						

Course Outcomes	
CO1	Liner algebra is a basic course in almost all branches of science. The objective of this course is to introduce a student to the basics of linear algebra andsome of its applications.
CO2	Students will be able to know the concepts of group, ring and other related properties which will prepare the students to take up further applications in the relevant fields.
CO3	The student will use this knowledge in computer science, finance mathematics, industrial mathematics and bio mathematics. After completion of this course students appreciate its interdisciplinary nature.

Part-A
Group and Ring Theory

Unit No.	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
I	Automorphism, inner automorphism, Automorphism groups, Automorphism groups of finite and infinite cyclic groups, Characteristic subgroups, Commutator subgroup and its properties; Applications of factor groups to automorphism groups.	10	2 & 3
II	Conjugacy classes, The class equation, *p*-groups, The Sylow theorems and consequences, Applications of Sylow theorems; Finite simple groups, Non-simplicity tests; Generalized Cayley's theorem, Index theorem, Embedding theorem and applications.	10	2 & 3
III	Polynomial rings over commutative rings, Division algorithm and consequences, Principal ideal domains, Factorization of polynomials, Reducibility tests, Irreducibility tests, Eisenstein criterion, Unique factorization in Z[x].	9	2 & 3
IV	Divisibility in integral domains, Irreducibles, Primes, Unique factorization domains, Euclidean domains.	9	2 & 3

Part-B
Mathematical Methods

Unit No.	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
V	Vector spaces, Subspaces, Linear independence and dependence of vectors, Basis and Dimension, Quotient space.	10	1 & 3
VI	Linear transformations, The Algebra of linear transformations, rank nullity theorem, their representation as matrices.	9	1 & 3
VII	Linear functionals, Dual space, Characteristic values, Cayley Hamilton Theorem.	9	1 & 3
VIII	Inner product spaces and norms, Cauchy-Schwarz inequality, Orthogonal vectors, Orthonormal sets and bases, Bessel's inequality for finite dimensional spaces, Gram-Schmidt orthogonalization process, Bilinear and Quadratic forms.	9	1 & 3

Reference Books: Part-A	
1.	I. N. Herstein, Topics in Algebra, John Wiley & Sons.
2.	Suggested digital plateform: NPTEL/SWAYAM/MOOCS.
Reference Books: Part-B	
1.	Linear Algebra by K. Hoffman and R. Kunze.
2.	Suggested digital plateform:NPTEL/SWAYAM/MOOCs

PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	1	3	3	2	3	3
CO2	2	2	2	1	3	2	1	2	2

CO3	3	3	2	1	2	3	2	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	B030502T / MT321	**Title of the Course**	Number Theory & Game Theory	**L**	**T**	**P**	**C**
Year	Third	**Semester**	Fifth	**4**	**1**	**0**	**5**
Pre-Requisite	Knowledge of Sets & Matrices	**Co-requisite**	None				
Course Objectives	The objective of the course is to develop the skills to apply the basic knowledge of Number theory. The course will further develop understanding the concepts of Game theory and their applications. The topics introduced will serve as basic tools for specialized studies in science field. After successfully completion of course, the student will able to explore subject knowledge into their respective dimensions.						

Course Outcomes	
CO1	Upon successful completion, students will have the knowledge and skills to solve problems in elementary number theory.
CO2	This course provides an introduction to Game Theory. Game Theory is a mathematical framework which makes possible the analysis of the decision making process of interdependent subjects. It is aimed at explaining and predicting how individual behaves in a specific strategic situation, and therefore help improve decision making.
CO3	A situation is strategic if the outcomes of decision problem depends n the choice of more than one person. Most decision problems in real life are strategic
CO4	To illustrate the concept, real-world examples, case studies, and classroom experiments might be used.

Part-A
Number Theory

Unit No.	Content of Unit	Contact Hrs.	Mapped CO
I	**Theory of Numbers:** Divisibility; Euclidean algorithm; primes; congruences; Fermat's theorem, Euler's theorem and Wilson's theorem; Fermat's quotients and their elementary consequences; solutions of congruences; Chinese remainder theorem; Euler's phi-function.	10	1 & 4
II	**Congruences:** Congruences modulo powers of prime; primitive roots and theirs existence; quadratic residues; Legendre symbol, Gauss' lemma about Legendre symbol; quadratic reciprocity law; proofs of various formulations; Jacobi symbol.	9	1 & 4
III	**Diophantine Equations:** Solutions of ax + by + c = 0, $x^n+y^n = z^n$; properties of Pythagorean triples; sums of two, four and five squares; assorted examples of Diophantine equations.	9	1 & 4
IV	**Generating Functions and Recurrence relations:** Generating Function Models, calculating coefficient of generating functions, partitions, Exponential Generating functions, A summation Method, Recurrence Relation Models, Divide and conquer Relations, solutions of Linear, Recurrence Relations, Solutions with Generating Functions .	9	1 & 4

Part-B
Game Theory

Unit No.	Content of Unit	Contact Hrs.	Mapped CO
V	Introduction, overview, uses of game theory, some applications and examples, and formal definitions of the normal forms, payoffs, mixed strategies, pure strategy, Nash equilibrium.	10	2
VI	Introduction, characteristics of game theory, Two-person zero-sum game, Pure and Mixed strategies, Saddle point and its existence.	10	2
VII	Fundamental Theorem of Rectangular games, Concept of Dominance and Graphical method of solving rectangular games.	9	3
VIII	Relationship between rectangular game and Linear Programming Problem, reduction of m× n game and solution of 2×2, 2×s and r × s cases by graphical method, algebraic and linear programming solution of m × n games.	9	3 & 4

Reference Books: Part-A

1. Niven, I., Zuckerman, H. S. and Montegomery, H.L. An Int. of the Theory of Numbers John Wiley and sons, 2003.
2. Burten, D.M., Elementary Number Theory (4th edition) Universal Book Stall, 2002.
3. B alakrishnan, V.K., Schaum's Outline of Theory and Problems of Combinatorics Including Concept of Graph Theory, McGraw Hill, 1995.
4. Balakrishnan, V.K., Introductory Discrete Mathematics, Dover Publications, 1996.
5. Suggested digital platform: NPTEL/SWAYAM/MOOCS.

Reference Books: Part-B

1. Martin Osborne, An Introduction to Game Theory, Oxford University Press, 2003.
2. Prajit Dutta, Strategies and Games, MIT Press, 1999. (WebsiteI: http://www.ece.stevens.tech.edu/~ccomanic/ee*00c.html)

3.	Allan Mac Kenzie, Game Theory for Wireless Engineers, Synthesis lectures on Communications, 2006.
4.	Suggested digital plateform:NPTEL/SWAYAM/MOOCs

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	3	3	2	3	3
CO2	3	1	2	2	2	3	1	1	2
CO3	2	1	1	1	2	1	2	1	1
CO4	2	2	1	1	2	2	1	1	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	B030503T / MT322	**Title of the Course**	Graph Theory & Discrete Mathematics	**L**	**T**	**P**	**C**
Year	Third	**Semester**	Fifth	**4**	**1**	**0**	**5**
Pre-Requisite	Knowledge of Sets, Relations and Matrices	**Co-requisite**	None				
Course Objectives	The objective of the course is to develop the skills to apply the basic knowledge of Graph theory. The course will further develop understanding the concepts of Discrete Mathematics and their applications. The topics introduced will serve as basic tools for specialized studies in science field. After successfully completion of course, the student will able to explore subject knowledge into their respective dimensions.						

Course Outcomes	
CO1	Upon successful completion, students will have the knowledge of various types of graphs, their terminology and applications.
CO2	After Successful completion of this course students will be able to understand the isomorphism and homomorphism of graphs. This course covers the basic concepts of graphs used in computer science and other disciplines. The topic includes path, circuits, adjacency matrix, tree, coloring. After successful completion of this course the student will have knowledge of graph coloring, color problem, vertex coloring.
CO3	After successful completion the student will have knowledge of Logic gates, Karanaugh maps and skills to proof by using truth table. After successful completion of this course the student will be able to apply the basics of the automation theory, transition function and table.
CO4	This course covers the basic concepts of discrete mathematics used in computer science, and other discipline that involve formal reasoning. The topic include logic, counting, relations, Hasse diagram and Boolean algebra. After successful completion of this course the student will have the knowledge in Mathematical reasoning, Combinatorial analysis, Discrete structures and Applications.

Part-A
Graph Theory

Unit No.	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
I	Introduction to graphs, basic properties of graphs, Simple graph, multi graph, graph terminology, representation of graph, Bipartite, regular, planar and connected components in graph, Euler graphs, Directed, Undirected, multi graph, mixed graph.	10	1
II	Walk and unilateral components, unicircle graphs, Hamiltonian path and circuits, Graph coloring, chromatics number, isomorphism and homomorphism of graphs, Incidence relation and degree of graph.	9	2
III	Operation of graph circuit, Path and circuits, Eulerian circuits, Hamiltonian path and cycles, Adjacency matrix, Weighted graph, Travelling salesman problem, shortest path, Dijkstra's algorithm.	9	2
IV	Tree, Binary and Spanning trees, coloring, color problems, Vertex coloring and important properties.	9	2

Part-B
Discrete Mathematics

Unit No.	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
V	**Propositional Logic-** Proposition logic, basic logic, logical connectives, truth tables, tautologies, contradiction, normal forms (conjunctive and disjunctive), modus ponens and modus tollens, validity, predicate logic, universal and existential quantification, proof by implication, converse, inverse contrapositive, contradiction, direct proof by using truth table.	10	3
VI	**Relation**- Definition, types of relation, domain and range of a relation, pictorial representation of relation, properties of relation, partial ordering relation, Representation of POSETS using Hasse diagram, Chains, Maximal and Minimal point, Glb, lub, Lattices and Algebraic system, basic properties, Sublattice.	10	4
VII	**Boolean Algebra-**Basic definitions, Sum of products and products of sums, Boolean Functions, Disjunctive normal form, Complete Disjunctive normal form, Conjugate normal form, Logic circuits, Logic networks, Design of circuits from given properties, Logic gates and Karnaugh maps.	9	4
VIII	**Combinatories**- Inclusion- exclusion, recurrence relations (nth order recurrence relation with constant coefficients, Homogeneous recurrence relations, Inhomogeneous recurrence relations), generating function (closed form expression, properties of G.F., solution of recurrence relations using G.F. solution of combinatorial problem using G.F.)	9	4

Reference Books: Part-A	
1.	Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Dover Publications, 2017.
2.	Douglas B West, Introduction to Graph Theory, Pearson 2018.
3.	Santanu Saha Ray, Graph Theory with Algorithm and Its Applications: In Applied Science and Technology, Springer India, 2012.
4.	Suggested digital plateform: NPTEL/SWAYAM/MOOCS.
Reference Books: Part-B	
1.	C. L.Liu., Discrete Mathematics, Tata McGraw Hill, 1986.
2.	Trembley and Manohar, Discrete Mathematics with computer application Tata McGraw Hill, 2008.
3.	Kenneth H. Rosen, Discrete Mathematics and Its Applications, McGraw Hill Companies, 2012.
4.	Suggested digital plateform: NPTEL/SWAYAM/MOOCs

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1	2	2	2	3	3
CO2	2	3	2	1	3	2	2	2	3
CO3	1	2	3	1	2	1	2	3	3
CO4	3	3	3	1	3	2	2	3	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	B030504T / MT323	**Title of the Course**	Differential Geometry & Tensor Analysis	**L**	**T**	**P**	**C**
Year	Third	**Semester**	Fifth	**4**	**1**	**0**	**5**
Pre-Requisite	Knowledge of Geometry	**Co-requisite**	None				
Course Objectives	The objective of the course is to develop the skills to apply the basic knowledge of Differential Geometry. The course will further develop understanding the concepts of Tensor Analysis and their applications. The topics introduced will serve as basic tools for specialized studies in science field. After successfully completion of course, the student will able to explore subject knowledge into their respective dimensions.						

Course Outcomes	
CO1	After successful completion of this course, students should be able to determine and calculate curvature of curves in different coordinates systems.
CO2	This course covers the Local theory of Curves, Local theory of surfaces, Geodesics, Geodesics curvature, Curvature of curves, on surfaces, Gaussian curvature, Normal curvature etc.
CO3	After Successful completion of this course, students should have the knowledge of tensor algebra, different types of tensors, Riemannian space, Ricci tensor, Einstein space and Einstein tensor etc.

Part-A
Differential Geometry

Unit No.	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
I	Local theory of curves-Space curves, Examples, Plane Curves, tangent and normal and binormal, osculating Plane, normal plane and rectifying plane, osculating circle, osculating sphere Helices, Serret-Frenet apparatus, contact between curve and surfaces, tangent surfaces, involutes and evolutes of curves, Bertrand curves, Intrinsic equations, fundamental existence theorem for space curves.	10	1
II	Local theory of Surfaces-Tangent plane, Normal, Parametric patches on surface curve of a surface, family of surfaces (one parameter). Edge of regression, rues surfaces, skew ruled surfaces and developable surfaces.	9	2
III	Metric-first fundamental form and second fundamental form and arc length, Direction coefficients, families of curves, intrinsic properties.	9	2
IV	Gauss-Bonnet theorem, curvature of curves on surfaces, Gaussian curvature, normal curvature, Meusneir's theorem, mean curvature, umbilic points, lines of curvature, Rodrigue's formula, Euler's theorem	9	1 & 2

Part-B
Tensor Analysis

Unit No.	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
V	Tensor Algebra: Vector spaces, the dual spaces, tensor product of vector spaces, transformation formulae, contraction, special tensors, symmetric tensor, inner product.	10	3
VI	Tensor Analysis: Contravariant and Covariant vectors and tensors, Mixed tensors, symmetric and skew-symmetric tensors, Algebra of tensors, Contraction and inner product, Quotient theorem, Reciprocal tensors, Christoffel's symbols, Law of transformation of Christoffel's symbols	10	3
VII	Gradient of scalars, Divergence of a contravariant vector, covariant vector and conservative vectors, Laplacian of an invariant, curl of a covariant vector	9	3
VIII	Riemannian space, Riemannian curvatures and their properties, Geodesics, Geodesics curvature, geometrical interpretation of curvature ensor.	9	3

Reference Books: Part-A

1. T. J. Willmore, An Introduction in Differential Geometry, Dover Publications, 2012.
2. B. O'Neill, Elementary Differential Geometry, 2nd Ed., Academic Press, 2006.
3. C. E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press 2003.
4. D. J. Struik, Lectures on Classical Differential Geometry, Dover Publications, 1988.
5. S. Lang, Fundamentals of Differential Geometry, Springer, 1999.
6. B. Spain, Tensor Calculus: A Concise course, Dover Publications, 2003.
7. L. P. Eisenhart, An Introduction to Differential Geometry (with the use of tensor Calculus), Princeton University Press, 1940.
8. I. S. Sokolnikoff, Tensor Analysis, Theory and Applications to Geometry and Mechanics of Continaa, 2nd Edition, John Wiley and Sons, 1964.

9.	Suggested digital plateform: NPTEL/SWAYAM/MOOCS.
Reference Books: Part-B	
1.	Z. Ahsan, Tensors-Mathematics of Differential Geometry, PHI, 2015.
2.	David C. Kay, Tensor Analysis, Schaum's Outline Series, McGraw Hill 1988.
3.	R. S. Mishra, A Course in Tensors with Applications to Riemannian Geometry, Pothishala Pvt Ltd, 1965.
4.	Suggested digital plateform:NPTEL/SWAYAM/MOOCs

PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1	2	2	3	2	2	3
CO2	3	3	1	1	2	3	2	2	2
CO3	3	3	1	2	3	3	2	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	B010501T/PY311	**Title of the Course**	Classical & Statistical Mechanics	**L**	**T**	**P**	**C**
Year	Third	**Semester**	Fifth	**4**	**0**	**0**	**4**
Pre-Requisite	10+2 with Physics	**Co-requisite**	Passed B.Sc. 2nd Year				
Course Objectives	This course aims to give students the competence in the basic Classical Mechanics and Statistical Mechanics. At the end of the course the students are expected to the thorough knowledge of basic concepts of Classical Mechanics and Statistical Mechanics.						

Course Outcomes	
CO1	Understand the concepts of generalized coordinates and D'Alembert's principle.
CO2	Understand the Lagrangian dynamics and the importance of cyclic coordinates.
CO3	Comprehend the difference between Lagrangian and Hamiltonian dynamics.
CO4	Study the important features of central force and its application in Kepler's problem.
CO5	Recognize the difference between macrostate and microstate.
CO6	Comprehend the concept of ensembles.
CO7	Understand the classical and quantum statistical distribution laws.
CO8	Study the applications of statistical distribution laws

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Constrained Motion**	Constraints - Definition, Classification and Examples. Degrees of Freedom and Configuration space. Constrained system, Forces of constraint and Constrained motion. Generalised coordinates, Transformation equations and Generalised notations & relations. Principle of Virtual work and D'Alembert's principle	6	CO1
2	**Lagrangian Formalism**	Lagrangian for conservative & non-conservative systems, Lagrange's equation of motion (no derivation), Comparison of Newtonian & Lagrangian formulations, Cyclic coordinates, and Conservation laws (with proofs and properties of kinetic energy function included). Simple examples based on Lagrangian formulation.	9	CO2
3	**Hamiltonian Formalism**	Phase space, Hamiltonian for conservative & non-conservative systems, Physical significance of Hamiltonian, Hamilton's equation of motion (no derivation), Comparison of Lagrangian & Hamiltonian formulations, Cyclic coordinates, and Construction of Hamiltonian from Lagrangian. Simple examples based on Hamiltonian formulation.	8	CO3
4	**Central Force**	Definition and properties (with prove) of central force. Equation of motion and differential equation of orbit. Bound & unbound orbits, stable & non-stable orbits, closed & open orbits and Bertrand's theorem. Motion under inverse square law of force and derivation of Kepler's laws. Laplace-Runge-Lenz vector (Runge-Lenz vector) and its applications.	7	CO4
5	**Macrostate and Microstate**	Macrostate, Microstate, Number of accessible microstates and Postulate of equal a priori. Phase space, Phase trajectory, Volume element in phase space, Quantisation of phase space and number of accessible microstates for free particle in 1D, free particle in 3D & harmonic oscillator in 1D.	6	CO5
6	**Concept of Ensemble**	Problem with time average, concept of ensemble, postulate of ensemble average and Liouville's theorem (proof included). Micro Canonical, Canonical & Grand Canonical ensembles. Thermodynamic Probability, Postulate of Equilibrium and Boltzmann Entropy relation.	6	CO6
7	**Distribution Laws**	Statistical Distribution Laws: Expressions for number of accessible microstates, probability & number of particles in ith state at equilibrium for Maxwell-Boltzmann, Bose-Einstein & Fermi- Dirac statistics. Comparison of statistical distribution laws and their physical significance. Canonical Distribution Law: Boltzmann's Canonical Distribution Law, Boltzmann's Partition Function, Proof of Equipartition Theorem (Law of Equipartition of energy) and relation between Partition function and Thermodynamic potentials.	10	CO7
8	**Applications of Statistical Distribution Laws**	Application of Bose-Einstein Distribution Law: Photons in a black body cavity and derivation of Planck's Distribution Law. Application of Fermi-Dirac Distribution Law: Free electrons in a metal, Definition of Fermi energy, Determination of Fermi energy at absolute zero, Kinetic energy of Fermi gas at absolute zero and concept of Density of States (Density of Orbitals).	8	CO8

Reference Books:

1. Herbert Goldstein, Charles P. Poole, John L. Safko, "Classical Mechanics", Pearson Education, India, 2011, 3e
2. N.C. Rana, P.S. Joag, "Classical Mechanics", McGraw Hill, 2017
3. R.G. Takwale, P.S. Puranik, "Introduction to Classical Mechanics", McGraw Hill, 2017
4. F. Reif, "Statistical Physics (In SI Units): Berkeley Physics Course Vol 5", McGraw Hill, 2017, 1e
5. B.B. Laud, "Fundamentals of Statistical Mechanics", New Age International Private Limited, 2020, 2e
6. B.K. Agarwal, M. Eisner, "Statistical Mechanics", New Age International Private Limited, 2007, 2e

e-Learning Source:

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

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)										
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	**3**	**2**	-	-	-	-	**3**	**2**	-	**1**	**2**
CO2	**3**	**2**	-	-	-	-	**3**	**3**	-	**1**	**2**
CO3	**3**	**2**	-	-	-	-	**3**	**3**	-	**2**	**2**
CO4	**3**	**2**	-	-	-	**1**	**3**	**3**	-	**3**	**2**
CO5	**3**	**2**	-	-	-	-	**3**	**3**	-	**3**	**2**
CO6	**3**	**2**	-	-	-	-	**3**	**2**	-	**1**	**2**
CO7	**3**	**2**	-	-	-	-	**3**	**3**	-	**1**	**2**
CO8	**3**	**2**	-	-	-	-	**3**	**3**	-	**2**	**2**

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	B010502T/PY312	**Title of the Course**	**Quantum Mechanics and Spectroscopy**	**L**	**T**	**P**	**C**
Year	Third	**Semester**	Fifth	**4**	**0**	**0**	**4**
Pre-Requisite	10+2 with Physics	**Co-requisite**	Passed B.Sc. 2nd Year				
Course Objectives	This course aims to give students the competence in the basic Quantum Mechanics and Spectroscopy. At the end of the course the students are expected to gain the thorough knowledge of basic Quantum Mechanics and Spectroscopy.						

Course Outcomes	
CO1	Understand the significance of operator formalism in Quantum mechanics.
CO2	Study the eigen and expectation value methods.
CO3	Understand the basis and interpretation of Uncertainty principle.
CO4	Develop the technique of solving Schrodinger equation for 1D and 3D problems.
CO5	Comprehend the success of Vector atomic model in the theory of Atomic spectra.
CO6	Study the different aspects of spectra of Group I and II elements.
CO7	Study the production and applications of X-rays.
CO8	Develop an understanding of the fundamental aspects of Molecular spectra.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Operator Formalism**	**Operators:** Review of matrix algebra, definition of an operator, special operators, operator algebra and operators corresponding to various physical-dynamical variables. **Commutators:** Definition, commutator algebra and commutation relations among position, linear momentum and angular momentum and energy and time. Simple problems based on commutation relations.	5	CO1
2	**Eigen and Expectation Values**	**Eigen and Expectation Values:** Eigen equation for an operator, eigen state (value) and eigen functions. Linear superposition of eigen functions and Non-degenerate and Degenerate eigen states. Expectation value pertaining to an operator and its physical interpretation. **Hermitian Operators:** Definition, properties and applications. Prove of the Hermitian nature of various physical-dynamical operators.	6	CO2
3	**Uncertainty Principle and Schrodinger Equation**	**Uncertainty Principle:** Commutativity and simultaneity (theorems with proofs). Non commutativity of operators as the basis for uncertainty principle and derivation of general form of uncertainty principle through Schwarz inequality. Uncertainty principle for various conjugate pairs of physical- dynamical parameters and its applications. **Schrodinger Equation:** Derivation of time independent and time dependent forms, Schrodinger equation as an eigen equation, Deviation and interpretation of equation of continuity in Schrodinger representation, and Equation of motion of an operator in Schrodinger representation.	7	CO3
4	**Applications of Schrodinger Equation**	**Application to 1D Problems:** Infinite Square well potential (Particle in 1D box), Finite Square well potential, Potential step, Rectangular potential barrier and 1D Harmonic oscillator. **Application to 3D Problems:** Infinite Square well potential (Particle in a 3D box) and the Hydrogen atom (radial distribution function and radial probability included). (Direct solutions of Hermite, Associated Legendre and Associated Laguerre differential equations to be substituted).	12	CO4
5	**Vector Atomic Model**	Inadequacies of Bohr and Bohr-Sommerfeld atomic models w.r.t. spectrum of Hydrogen atom (fine structure of H-alpha line). Modification due to finite mass of nucleus and Deuteron spectrum. Vector atomic model (Stern-Gerlach experiment included) and physical and geometrical interpretations of various quantum numbers for single and many valence electron systems. LS and JJ couplings, spectroscopic notation for energy states, selection rules for transition of electrons and intensity rules for spectral lines. Fine structure of H-alpha line on the basis of vector atomic model.	10	CO5
6	**Spectra of Alkali and Alkaline Elements**	**Spectra of Alkali Elements:** Screening constants for s, p, d and f orbitals; sharp, principle, diffuse and fundamental series; doublet structure of spectra and fine structure of Sodium D line. **Spectra of Alkaline Elements:** Singlet and triplet structure of spectra.	6	CO6
7	**X – Rays and X – Ray Spectra**	Nature and production, Continuous X-ray spectrum and Duane-Hunt's law, Characteristic X-ray spectrum and Mosley's law, Fine structure of Characteristic X-ray spectrum, and X-ray absorption spectrum.	7	CO7
8	**Molecular Spectra**	Discrete set of energies of a molecule, electronic, vibrational and rotational energies. Quantisation of vibrational energies, transition rules and pure vibrational spectra. Quantisation of rotational energies, transition rules, pure rotational spectra and determination of inter nuclear distance. Rotational-Vibrational spectra; transition rules; fundamental band and hot band; O, P, Q, R, S branches.	7	CO8

Reference Books:

1. D.J. Griffiths, "Introduction to Quantum Mechanics", Pearson Education, India, 2004, 2e
2. E. Wichmann, "Quantum Physics (In SI Units): Berkeley Physics Course Vol 4", McGraw Hill, 2017
3. Richard P. Feynman, Robert B. Leighton, Matthew Sands, "The Feynman Lectures on Physics - Vol. 3", Pearson Education Limited, 2012
4. R Murugeshan, Kiruthiga Sivaprasath, "Modern Physics", S. Chand Publishing, 2019, 18e
5. H.E. White, "Introduction to Atomic Spectra", McGraw Hill, 1934
6. C.N. Banwell, E.M. McCash, "Fundamentals of Molecular Spectroscopy", McGraw Hill, 2017, 4e
7. S.L. Gupta, V. Kumar, R.C. Sharma, "Elements of Spectroscopy", Pragati Prakashan, Meerut, 2015, 27e

e-Learning Source:

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

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)										
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	**3**	**2**	-	-	-	-	**3**	**2**	-	**1**	**2**
CO2	**3**	**2**	-	-	-	-	**3**	**3**	-	**1**	**2**
CO3	**3**	**2**	-	-	-	-	**3**	**3**	-	**2**	**2**
CO4	**3**	**2**	-	-	-	-	**3**	**3**	-	**3**	**2**
CO5	**3**	**2**	-	-	-	-	**3**	**3**	-	**3**	**2**
CO6	**3**	**2**	-	-	-	-	**3**	**2**	-	**1**	**2**
CO7	**3**	**2**	-	-	-	-	**3**	**3**	-	**1**	**2**
CO8	**3**	**2**	-	-	-	-	**3**	**3**	-	**2**	**2**

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name and Sign of Program Coordinator	**Sign and Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	B010503P/PY313	**Title of the Course**	**Demonstrative Aspects of Optics & Lasers**	**L**	**T**	**P**	**C**
Year	**Third**	**Semester**	Fifth	**0**	**0**	**4**	**2**
Pre-Requisite	10+2 with Physics	**Co-requisite**	Passed B.Sc. 2nd Year				
Course Objectives	The purpose of this undergraduate course is to impart practical knowledge/measurements in Optics through different experiments related to its theoretical course.						

Course Outcomes	
CO1	To understand the application of Fresnel's Biprism in determination of Wavelength of Light and thickness of a thin sheet.
CO2	To understand the application of Newton's Ring in determination of Wavelength of Light and Refractive Index of a Transparent Liquid.
CO3	To find the Resolving Power of a grating and to understand its application in determination of wavelength of different colours of light.
CO4	To find the dispersive power of a prism and refractive index of its material using spectrometer.
CO5	To find the specific resistance of sugar solution using polarimeter and wavelength of Laser light using single slit diffraction.

*** A student has to perform at least 7 experiments from the Offline Experiment List and 3 from the Online Virtual Lab Experiment List / Link.**

Experiment No.	**Title of the Experiment**	**Content of Unit (*Offline)**	**Contact Hrs.**	**Mapped CO**
1	Wavelength by Fresnel's Biprism	Fresnel Biprism: Wavelength of sodium light	4	CO1
2	Thickness by Fresnel's Biprism	Fresnel Biprism: Thickness of mica sheet	4	CO1
3	Wavelength by Newton's Ring	Newton's Rings: Wavelength of sodium light	4	CO2
4	Refractive Index by Newton's Ring	Newton's Rings: Refractive index of liquid	4	CO2
5	Resolving power of Grating	Plane Diffraction Grating: Resolving power	4	CO3
6	Wavelength by Diffraction Grating	Plane Diffraction Grating: Spectrum of mercury light	4	CO3
7	Refractive index of Prism	Spectrometer: Refractive index of the material of a prism using sodium light	4	CO4
8	Dispersive Power of Prism	Spectrometer: Dispersive power of the material of a prism using mercury light	4	CO4
9	Specific Rotation by Polarimeter	Polarimeter: Specific rotation of sugar solution	4	CO5
10	Wavelength of Laser Light	Wavelength of Laser light using diffraction by single slit	4	CO5
Experiment No.	**Title of the Experiment**	**Content of Unit (*Online Virtual Lab)**	**Contact Hrs.**	**Mapped CO**
1	Michelson's Interferometer - Working	Michelson's Interferometer	4	CO1
2	Wavelength by Michelson's Interferometer	Michelson's Interferometer: Wavelength of laser beam	4	CO4
3	Wavelength by Newton's Ring	Newton's Rings: Wavelength of light	4	CO1
4	Refractive Index by Newton's Ring	Newton's Rings: Refractive index of liquid	4	CO4
5	Brewster's Law	Brewster's angle determination	4	CO4
6	Laser Beam Divergence	Laser beam divergence and spot size	4	CO2
7	Refractive index of Prism	Spectrometer: Refractive index of the material of a prism	4	CO4
8	Dispersive Power of Prism	Spectrometer: Dispersive power of a prism	4	CO2
9	Cauchy's Constant	Spectrometer: Determination of Cauchy's constants	4	
10	Wavelength by Diffraction Grating	Diffraction Grating	4	

Reference Books:

1. B.L. Worsnop, H.T. Flint, "Advanced Practical Physics for Students", Methuen & Co., Ltd., London, 1962, 9e
2. S. Panigrahi, B. Mallick, "Engineering Practical Physics", Cengage Learning India Pvt. Ltd., 2015, 1e
3. R.K. Agrawal, G. Jain, R. Sharma, "Practical Physics", Krishna Prakashan Media (Pvt.) Ltd., Meerut, 2019
4. S.L. Gupta, V. Kumar, "Practical Physics", Pragati Prakashan, Meerut, 2014, 2e

e-Learning Source:

1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74
2. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/index.php?sub=1&brch=281
3. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities.

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)										
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	**2**	---	---	---	---	---	**3**	**3**	---	---	**3**
CO2	**2**	---	---	---	---	---	**3**	**3**	---	---	**3**
CO3	**3**	---	---	---	---	---	**2**	**3**	---	---	**3**
CO4	**2**	---	---	---	---	---	**3**	**3**	---	---	**3**
CO5	**3**	---	---	---	---	---	**2**	**3**	---	**2**	**3**

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	B070501T/CS365	**Title of the Course**	Analysis of Algorithms and Data Structures	**L**	**T**	**P**	**C**
Year	Third	**Semester**	Fifth	**4**	**1**	**0**	**5**
Pre-Requisite	Mathematics in class 12th and Computer Fundamental, and C++ and Object OrientedProgramming	**Co-requisite**	None				
Course Objectives	This course introduces students to the analysis and design of computer algorithms. Upon completion of this course, students will be able to do the following: Analyze the asymptotic performance of algorithms. Demonstrate a familiarity with major algorithms and data structures. Apply important algorithmic design paradigms and methods of analysis. Synthesize efficient algorithms in common engineering design situation.						

Course Outcomes	
CO1	Understand that various problem solving categories exist such as; iterative technique, divide and conquer, dynamic programming, greedy algorithms, and understand various searching and sorting algorithms
CO2	Employ a deep knowledge of various data structures when constructing a program..
CO3	Design and construct simple object-oriented software with an appreciation for dataabstraction and information hiding.
CO4	Effectively use software development tools including libraries, compilers, editors,linkers and debuggers to write and troubleshoot programs.

Unit No.	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
I	**Introduction**: Basic Design and Analysis techniques of Algorithms, time and space complexity, Correctness of Algorithm, Algorithm Design Techniques: Iterative techniques, Divide and Conquer, Dynamic Programming, Greedy Algorithms.	7	2 & 3
II	**Sorting Techniques**: Elementary sorting techniques-BubbleSort, Insertion Sort, Merge Sort, Advanced Sorting techniques-Heap Sort, Quick Sort, Sorting in Linear Time-Bucket Sort, Radix Sort and Count Sort	8	4 & 3
III	**Searching Techniques and Complexity Analysis:** Linear and Binary search, Medians & Order Statistics.	7	2 & 3
IV	**Arrays** Arrays: Single and Multi-dimensional Arrays,Sparse Matrices;	7	2 & 3
V	**Stacks and Queues :** Implementing stack using array and linked list, Prefix, Infix and Postfix expressions, Utility and conversion of these expressions from one to another; Array and Linked representation of Queue, De-queue, Priority Queues	8	4 & 3
VI	**Linked Lists:** Singly, Doubly and Circular Lists, representationof Stack and Queue as Linked Lists.	8	1 & 3
VII	**Recursion**: Developing Recursive Definition of Simple Problems and their implementation; Advantages and Limitations of Recursion;	7	1 & 4
VIII	**Trees**: Introduction to Tree as a data structure; Binary Trees, Binary Search Tree, (Creation, and Traversals of Binary Search Trees)	8	1 & 3

Reference Books: Part-A
Cormen T.H., Leiserson Charles E., Rivest Ronald L., Stein Clifford, Introductionto Algorithms, PHI Learning Pvt. Ltd., 2009, 3rd Edition.
Basse Sara & A.V. Gelder, Computer Algorithm: Introduction to Design andAnalysis, Pearson, 2000, 3rd Editionn
Drozdek Adam, "Data Structures and algorithm in C++", Cengage Learning, 2012,Third Edition.
Tenenbaum Aaron M., Augenstein Moshe J., Langsam Yedidyah, "Data StructuresUsing C and C++, PHI, 2009, Second edition.

PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	1	3	3	2	3	3
CO2	2	2	2	1	3	2	1	2	2
CO3	3	3	2	1	2	3	2	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	B070502T/CS366	**Title of the Course**	Soft Computing	**L**	**T**	**P**	**C**
Year	Third	**Semester**	Fifth	**4**	**1**	**0**	**5**
Pre-Requisite	Mathematics in class 12th	**Co-requisite**	None				
Course Objectives	Upon the completion of this course the student will have the knowledge of soft computing concepts and he can apply them for practical applications. He would be able to choose and design suitable Neural Network for real time problems. He can appropriately use fuzzy rules and reasoning to develop decision making and expert systems. He would know the importance of optimization techniques and genetic programming.						

Course Outcomes	
CO1	Understand that various problem solving categories exist such as; iterative technique, divide and conquer, dynamic programming, greedy algorithms, and understand various searching and sorting algorithms
CO2	Employ a deep knowledge of various data structures when constructing a program.
CO3	Design and construct simple object-oriented software with an appreciation for dataabstraction and information hiding.
CO4	Effectively use software development tools including libraries, compilers, editors, linkers and debuggers to write and troubleshoot programs.

Unit No.	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
I	**Introduction To Neural Networks**: Neural Networks Neuron, Nerve Structure And Synapse, Artificial Neuron AndIts Model, Activation Functions.	7	2 & 3
II	**Neural Network Architecture**: Single Layer And MultilayerFeed Forward Networks, Recurrent Networks. Perception And Convergence Rule.Supervised Learning Network& Unsupervised Learning Network.	8	4 & 3
III	**Back Propogation Networks-I**: Perceptron Model, Solution, Single Layer, Multilayer Perception Model;	7	2 & 3
IV	**Back Propogation Networks**-II: Back Propogation Learning Methods, Effect Of Learning Rule Co-Efficient ;Back Propagation Algorithm, Applications.	8	2 & 3
V	**Fuzzy Logic Introduction-I**: Basic Concepts Of Fuzzy Logic, Fuzzy Sets And Crisp Sets, Fuzzy Set Theory AndOperations, Properties Of Fuzzy Sets	7	4 & 3
VI	**Fuzzy Logic Introduction-II:** Fuzzy And Crisp Relations, Fuzzy To Crisp Conversion, Membership Functions, Interference In Fuzzy Logic, Fuzzy If-Then Rules, Fuzzyfications&Defuzzificataions.	8	1 & 3
VII	**Genetic Algorithm-I**: Basic Concepts, Working Principle,Procedures Of GA, Flow Chart Of GA	7	1 & 4
VIII	**Genetic Algorithm-II:** Genetic Representations, (Encoding),Genetic Operators, Mutation, Generational Cycle.	8	1 & 3

Reference Books: Part-A
S. Rajsekaran & G.A. VijayalakshmiPai, "Neural Networks, Fuzzy Logic and GeneticAlgorithm: Synthesis and Applications" Prentice Hall of India,2003
Anderson, James, "Introduction to Neural Networks", PHI Publication, Delhi, India
N.P.Padhy,"Artificial Intelligence and Intelligent Systems" Oxford University Press, USA,2005.
Simon Haykin,"Neural Netowrks and Learning Machines "Prentice Hall of India, 2005,Third Edition.

PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	1	3	3	2	3	3
CO2	2	2	2	1	3	2	1	2	2
CO3	3	3	2	1	2	3	2	2	2
CO4	3	3	2	1	2	3	2	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	B070503P/CS367	**Title of the Course**	**Lab on Algorithm and Data Structures with C++**	**L**	**T**	**P**	**C**
Year	**Third**	**Semester**	**Fifth**	**0**	**0**	**4**	**2**
Pre-Requisite	10+2 with Mathematics	**Co-requisite**					
Course Objectives							

Course Outcomes	
CO1	Optimize the solution with respect to time complexity & memory usage
CO2	Assess how the choice of data structures and algorithm design methods impacts theperformance of programs.
CO3	Choose the appropriate data structure and algorithm design method for a specifiedapplication.
CO4	Solve problems using data structures such as linear lists, stacks, queues, binary trees,binary search trees and writing programs for these solutions

Experiment No.	**Title of the Experiment**	**Content of Experiment**	**Contact Hrs.**	**Mapped CO**
1		Write a program that uses functions to perform the following: Create a singly linked list of integers. Delete a given integer from the above linked list. Display the contents of the above list after deletion.	2	1
2		Write a program that uses functions to perform the following: Create a doubly linked list of integers. Delete a given integer from the above doubly linked list. Display the contents of the above list after deletion.	2	1
3		Write a program that uses stack operations to convert a given infix expression into itspostfix Equivalent, implement the stack using an array.	2	2
4		Write program to implement a double ended queue using array and doubly linked list respectively.	2	2
5		Write a program that uses functions to perform the following: Create a binary search tree of characters. Binary search tree recursively in Postorder.	2	3
6		Write a program that uses functions to perform the following: Create a binary search tree of integers. Traverse the above Binary search tree non recursively in inorder.	4	3
7		Write program for implementing the following sorting methods to arrange a list ofintegers in ascending order: Insertion sort	4	4
8		Write program for implementing the following sorting methods to arrange a list ofintegers in ascending order: Quick sort Selection sort	4	4
9		Write program to implement Insertion Sort (The program should report the number ofcomparisons)	4	3
10		Write program implement Merge Sort(The program should report the number ofcomparisons)	4	4
11		Write program implement Heap Sort (The program should report the number ofcomparisons)	2	3
12		Write program implement Randomized Quick sort (The program should reportthe number of comparisons)	2	2
13		Write program for creation and traversal of Binary Search Tree.	2	4

Reference Books:

1. Cochran, W. G. and Cox, G. M. (1957). Experimental Design. John Wiley & Sons, New York.

2. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.Kshirsagar, A.M. (1972): Multivariate Analysis, 1stEdn. Marcel Dekker.
3. Gibbons, J. D. and Chakraborty, S (2003): Nonparametric Statistical Inference. 4th Edition.Marcel Dekker, CRC

e-Learning Source:

Suggestive digital platforms web link/platform: NPTEL/SWAYAM/MOOCS

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)											
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3						3	3	3	3	3	3
CO2	3						2	3	2	3	3	2
CO3	3						3	3	2	2	2	1
CO4	3						2	3	2	2	3	2
CO5	3						2	3	3	3	3	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	B030502T / MT324	**Title of the Course**	Metric Spaces & Complex Analysis	**L**	**T**	**P**	**C**
Year	Third	**Semester**	Sixth	**3**	**1**	**0**	**4**
Pre-Requisite	Knowledge of sets, limit, continuity & differentiability.	**Co-requisite**	None				
Course Objectives	The objective of the course is to develop the skills to apply the basic knowledge of Metric Spaces. The course will further develop understanding the concepts of Complex Analysis and their applications. The topics introduced will serve as basic tools for specialized studies in science field. After successfully completion of course, the student will able to explore subject knowledge into their respective dimensions.						

Course Outcomes	
CO1	The course is aimed at exposing the students to foundations of analysis which will be useful in understanding various physical phenomena and gives the student the foundation in mathematics.
CO2	After completion of this course the student will have rigorous and deeper understanding of fundamental concepts in Mathematics. This will be helpful tothe student in understanding pure mathematics and in research.
CO3	Students will be able to know the concepts of metric space, basic concepts and developments of complex analysis which will prepare the students to take up further applications in the relevant fields.

Part-A

Metric Spaces

Unit No.	Content of Unit	Contact Hrs.	Mapped CO
I	**Basic Concepts:** Metric spaces**:** Definition and examples, Sequences in metric spaces, Cauchy sequences, Complete metric space.	8	1 & 3
II	**Topology of Metric Spaces:** Open and closed ball, Neighborhood, Open set, Interior of a set, limit point of a set, derived set, closed set, closure of a set, diameter of a set, Cantor's theorem, Subspaces, Dense set.	8	1 & 3
III	**Continuity & Uniform Continuity in Metric Spaces:** Continuous mappings, Sequential criterion and other characterizations of continuity, Uniform continuity, Homeomorphism, Contraction mapping, Banach fixed point theorem.	7	1 & 3
IV	**Connectedness and Compactness:** Connectedness, Connected subsets of real numbers, Connectedness and continuous mappings, Compactness, Compactness and boundedness,Continuous functions on compact spaces.	7	1 & 3

Part-B

Complex Analysis

Unit No.	Content of Unit	Contact Hrs.	Mapped CO
V	**Analytic Functions and Cauchy-Riemann Equations:** Functions of complex variable, Mappings; Mappings by the exponential function, Limits, Theorems on limits, Limits involving the point at infinity, Continuity, Derivatives, Differentiation formulae, Cauchy-Riemann equations, Sufficient conditions for differentiability; Analytic functions and their examples.	8	1 & 2
VI	**Elementary Functions and Integrals:** Exponential function, Logarithmic function, Branches and derivatives of logarithms, Trigonometric function, Derivatives of functions, Definite integrals of functions, Contours, Contour integrals and its examples, Upper bounds for moduli of contour integrals.	8	1 & 2
VII	**Cauchy's Theorems and Fundamental Theorem of Algebra:** Antiderivatives, Proof of antiderivative theorem, Cauchy-Goursat theorem, Cauchy integral formula; An extension of Cauchy integral formula, Consequences of Cauchy integral formula, Liouville's theorem and the fundamental theorem of algebra.	**7**	1 & 2
VIII	**Series and Residues:** Convergence of sequences and series, Taylor series and its examples; Laurent series and its examples, Absolute and uniformconvergence of power series, Uniqueness of series representations of power series, Isolated singular points, Residues, Cauchy's residue theorem, residue at infinity; Types of isolated singular points, Residues at poles and its examples.	**7**	1 & 2

Reference Books: Part-A

1. Mathematical Analysis by Shanti Narain.
2. Shirali, Satish & Vasudeva, H. L. (2009). Metric Spaces, Springer, First Indian Print.
3. Kumaresan, S. (2014). Topology of Metric Spaces (2nd ed.). Narosa Publishing House. New Delhi.
4. Simmons, G. F. (2004). Introduction to Topology and Modern Analysis.Tata McGraw Hill. New Delhi.

5.	Suggested digital plateform: NPTEL/SWAYAM/MOOCS.
Reference Books: Part-B	
1.	Function of Complex Variable by Shanti Narain.
2.	Complex variable and applications by Brown & Churchill.
3.	Suggested digital plateform: NPTEL/SWAYAM/MOOCs

PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	1	3	3	3	2	3
CO2	3	3	2	1	3	3	2	2	3
CO3	3	3	3	1	3	3	3	3	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	B030602T / MT325	**Title of the Course**	Numerical Analysis & Operation Research	**L**	**T**	**P**	**C**
Year	Third	**Semester**	Sixth	**3**	**1**	**0**	**4**
Pre-Requisite	Knowledge of errors and system of linear equations.	**Co-requisite**	None				
Course Objectives	The objective of the course is to develop the skills to apply the basic knowledge of Numerical Analysis. The course will further develop understanding the concepts of Operation Research and their applications. The topics introduced will serve as basic tools for specialized studies in science field. After successfully completion of course, the student will able to explore subject knowledge into their respective dimensions.						

Course Outcomes	
CO1	The aim of this course is to teach the student the application of various numerical technique for variety of problems occurring in daily life. At the end of the course the student will be able to understand the basic concept of Numerical Analysis and to solve algebraic and differential equation.
CO2	The main outcome will be that students will be able to handle problems and finding approximated solution. Later he can opt for advance course in Numerical Analysis in higher Mathematics.
CO3	The student will be able to solve various problems based on linear programming. After successful completion of this paper will enable the students to apply the basic concepts of operations research.

Part-A

Numerical Analysis

Unit No.	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
I	Solution of equations: bisection, Secant, Regular Falsi, Newton Raphson's method, Newton's method for multiple roots, Interpolation, Lagrange and Hermite interpolation, Difference schemes, Divided differences, Interpolation formula using differences.	8	1 & 2
II	Numerical differentiation, Numerical Quadrature: Newton Cotes Formulas, Gaussian Quadrature Formulas, System of Linear equations: Direct method for solving systems of linear equations (Gauss elimination, LU Decomposition, Cholesky Decomposition), Iterative methods (Jacobi, Gauss Seidel, Relaxation methods). The Algebraic Eigen value problem: Jacobi's method, Givens method,Power method.	8	1 & 2
III	Numerical solution of Ordinary differential equations: Euler method, single step methods, Runge-Kutta method, Multi-step methods: Milne-Simpson method, Types of approximation: Last Square polynomial approximation, Uniform approximation, Chebyshev polynomial approximation.	7	1 & 2
IV	Difference Equations and their solutions, Shooting method and Difference equation method for solving Linear second order differential equation with boundary conditions of first, second and third type.	7	1 & 2

Part-B

Operation Research

Unit No.	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
V	Introduction, Linear programming problems, statement and formation of general linear programming problems, graphical method, slack and surplus variables, standard and matrix forms of linear programming problem, basic feasible solution.	8	3
VI	Convex sets, fundamental theorem of linear programming, basic solution, Simplex method, introduction to artificial variables, two phase method Big-M method and their comparison.	8	3
VII	Resolution of degeneracy, duality in linear programming problems, primal dual relationships, revised simplex method, sensitivity analysis.	**7**	3
VIII	Transportation problems, assignment problems.	**7**	3

Reference Books: Part-A	
1.	Numerical Methods for Engineering and scientific computation by M. K. Jain, S.R.K. Iyengar & R.K. Jain.
1.	Introductory methods of Numerical Analysis by S. S. Sastry..
2.	Suggested digital plateform: NPTEL/SWAYAM/MOOCS.
Reference Books: Part-B	
1.	Taha, Hamdy H, "Opearations Research- An Introduction ", Pearson Education.

2.	Gupta, Prem Kumar, Initials, " Operations Research", Chand (S) & Co Ltd, India.
3.	Hillier Frederick S and Lieberman Gerald J., “Operations Research”, McGraw Hill Publication
4.	Winston Wayne L., “Operations Research: Applications and Algorithms”, Cengage Learning, 4th Edition.
5.	Hira D.S. and Gupta Prem Kumar, “Problems in Operations Research: Principles and Solutions”, S Chand & Co Ltd
6.	Kalavathy S., “Operations Research”, S Chand.
7.	Suggested digital plateform:NPTEL/SWAYAM/MOOCs.

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	1	2	2	3	3	3
CO2	3	3	3	1	2	2	3	3	3
CO3	2	2	3	1	2	2	2	3	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	B030603P / MT326	**Title of the Course**	Practical Using Mathematica/MATLAB	**L**	**T**	**P**	**C**
Year	Third	**Semester**	Sixth	**0**	**0**	**4**	**4**
Pre-Requisite	Knowledge of numerical analysis.	**Co-requisite**	None				
Course Objectives	The main objective of the course is to equip the student to solve the transcendental and algebraic equations, system of linear equations, ordinary differential equations, Interpolation, Numerical Integration, Method of finding Eigenvalue by Power method (up to 4 × 4), Fitting a Polynomial Function (up to third degree).						

Unit No.	Topics	No. of Lectures
I	**Practical / Lab work to be performed in Computer Lab.** List of the practicals to be done using computer algebra software (CAS), for example R/Python/Mathematica/MATLAB/Maple/Maxima/Scilab etc 1. Solution of transcendental and algebraic equations by i) Bisection method ii) Newton Raphson method (Simple root, multiple roots, complex roots). iii) Secant method. iv) Regula Falsi method. 2. Solution of system of linear equations i) LU decomposition method ii) Gaussian elimination method iii) Gauss-Jacobi method iv) Gauss-Seidel method 3. Interpolation i) Lagrange Interpolation ii) Newton's forward, backward and divided difference interpolations 4. Numerical Integration i) Trapezoidal Rule ii) Simpson's one third rule iii) Weddle's Rule iv) Gauss Quadrature 5. Method of finding Eigenvalue by Power method (up to 4 × 4) 6. Fitting a Polynomial Function (up to third degree) 7. Solution of ordinary differential equations i) Euler method ii) Modified Euler method iii) Runge Kutta method (order 4) The method of successive approximations (Picard)	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	B010601T/PY314	**Title of the Course**	**Solid State and Nuclear Physics**	**L**	**T**	**P**	**C**
Year	Third	**Semester**	Sixth	**4**	**0**	**0**	**4**
Pre-Requisite	10+2 with Physics	**Co-requisite**	Passed B.Sc. 2nd Year				
Course Objectives	This course aims to give students the competence in the basic Solid State and Nuclear Physics. At the end of the course the students are expected to gain the thorough knowledge of Solid State and Nuclear Physics.						

Course Outcomes	
CO1	Understand the crystal geometry w.r.t. symmetry operations.
CO2	Comprehend the power of X-ray diffraction and the concept of reciprocal lattice.
CO3	Study various properties based on crystal bindings.
CO4	Recognize the importance of Free Electron and Band theories in understanding the crystal properties.
CO5	Study the salient features of nuclear forces and radioactive decays.
CO6	Understand the importance of nuclear models and nuclear reactions.
CO7	Comprehend the working and applications of nuclear accelerators and detectors.
CO8	Understand the classification and properties of basic building blocks of nature.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Crystal Structure**	Lattice, Basis and Crystal structure. Lattice translation vectors, Primitive and non-primitive cells. Symmetry operations, Point group and Space group. 2D and 3D Bravais lattice. Parameters of cubic lattices. Lattice planes and Miller indices. Simple crystal structures - HCP and FCC, Diamond, Cubic. Zinc Sulphide, Sodium Chloride, Cesium Chloride and Glasses.	7	CO1
2	**Crystal Diffraction**	X-ray diffraction and Bragg's law. Experimental diffraction methods - Laue, Rotating crystal and Powder methods. Derivation of scattered wave amplitude. Reciprocal lattice, Reciprocal lattice vectors and relation between Direct and Reciprocal lattice. Diffraction conditions, Ewald's method and Brillouin zones. Reciprocal lattice to SC, BCC and FCC lattices. Atomic Form factor and Crystal Structure factor.	7	CO2
3	**Crystal Binding**	Classification of Crystals on the Basis of Bonding - Ionic, Covalent, Metallic, van der Waals (Molecular) and Hydrogen bonded. Crystals of inert gases, Attractive interaction (van der Waals- London) and Repulsive interaction, Equilibrium lattice constant, Cohesive energy and Compressibility and Bulk modulus. Ionic crystals, Cohesive energy, Madelung energy and evaluation of Madelung constant.	7	CO3
4	**Lattice Vibrations**	**Lattice Vibrations:** Lattice vibrations for linear mono and di atomic chains, Dispersion relations and Acoustical and Optical branches (qualitative treatment). Qualitative description of Phonons in solids. Lattice heat capacity, Dulong-Petit's law and Einstein's theory of lattice heat capacity. **Free Electron Theory:** Fermi energy, Density of states, Heat capacity of conduction electrons, Paramagnetic susceptibility of conduction electrons and Hall effect in metals. **Band Theory:** Origin of band theory, Qualitative idea of Bloch theorem, Kronig-Penney model, Effective mass of an electron and Concept of Holes and Classification of solids on the basis of band theory.	9	CO4
5	**Nuclear Forces and Radioactive Decays**	**General Properties of Nucleus:** Mass, binding energy, radii, density, angular momentum, magnetic dipole moment vector and electric quadrupole moment tensor. **Nuclear Forces:** General characteristic of nuclear force and Deuteron ground state properties. **Radioactive Decays:** Nuclear stability, basic ideas about beta minus decay, beta plus decay, alpha decay, gamma decay and electron capture, fundamental laws of radioactive disintegration and radioactive series.	9	CO5
6	**Nuclear Models and Nuclear Reactions**	**Nuclear Models:** Liquid drop model and Bethe-Weizsacker mass formula. Single particle shell model (the level scheme in the context of reproduction of magic numbers included). **Nuclear Reactions:** Bethe's notation, types of nuclear reaction, Conservation laws, Cross-section of nuclear reaction, Theory of nuclear fission (qualitative), Nuclear reactors and Nuclear fusion.	9	CO6
7	**Accelerators and Detectors**	**Accelerators:** Theory, working and applications of Van de Graaff accelerator, Cyclotron and Synchrotron. **Detectors:** Theory, working and applications of GM counter, Semiconductor detector, Scintillation counter and Wilson cloud chamber.	6	CO7
8	**Elementary Particles**	Fundamental interactions and their mediating quanta. Concept of antiparticles. Classification of elementary particles based on intrinsic-spin, mass, interaction and lifetime. Families of Leptons, Mesons, Baryons and Baryon Resonances. Conservation laws for mass-energy, linear momentum, angular momentum, electric charge, baryonic charge, leptonic charge, isospin and strangeness. Concept of Quark model.	6	CO8

Reference Books:

1. Charles Kittel, "Introduction to Solid State Physics", Wiley India Private Limited, 2012, 8e
2. A.J. Dekker, "Solid State Physics", Macmillan India Limited, 1993
3. R.K. Puri, V.K. Babbar, "Solid State Physics", S. Chand Publishing, 2015
4. Kenneth S. Krane, "Introductory Nuclear Physics", Wiley India Private Limited, 2008
5. Bernard L. Cohen, "Concepts of Nuclear Physics", McGraw Hill, 2017
6. S.N. Ghoshal, "Nuclear Physics", S. Chand Publishing, 2019

e-Learning Source:

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

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)										
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	**3**	**2**	-	-	-	-	**3**	**2**	-	**1**	**2**
CO2	**3**	**2**	-	-	-	-	**3**	**3**	-	**1**	**2**
CO3	**3**	**2**	-	-	-	-	**3**	**3**	-	**2**	**2**
CO4	**3**	**2**	-	-	-	-	**3**	**3**	-	**3**	**2**
CO5	**3**	**2**	-	-	-	-	**3**	**3**	-	**3**	**2**
CO6	**3**	**2**	-	-	-	-	**3**	**2**	-	**1**	**2**
CO7	**3**	**2**	-	-	-	-	**3**	**3**	-	**1**	**2**
CO8	**3**	**2**	-	-	-	-	**3**	**3**	-	**2**	**2**

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name and Sign of Program Coordinator	**Sign and Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	B010602T/PY315	**Title of the Course**	**Analog & Digital Principles & Applications**	**L**	**T**	**P**	**C**
Year	Third	**Semester**	Sixth	**4**	**0**	**0**	**4**
Pre-Requisite	10+2 with Physics	**Co-requisite**	Passed B.Sc. 2nd Year				
Course Objectives	This course aims to give students the competence in Analog and Digital Electronics. At the end of the course the students are expected to gain the thorough knowledge of Analog and Digital Electronics and their applications in daily life.						

Course Outcomes	
CO1	Study the drift and diffusion of charge carriers in a semiconductor.
CO2	Understand the Two-Port model of a transistor.
CO3	Study the working, properties and uses of FETs.
CO4	Comprehend the design and operations of SCRs and UJTs.
CO5	Understand various number systems and binary codes.
CO6	Familiarize with binary arithmetic.
CO7	Study the working and properties of various logic gates.
CO8	Comprehend the design of combinational and sequential circuits.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Semiconductor Junction**	Expressions for Fermi energy, Electron density in conduction band, Hole density in valence band, Drift of charge carriers (mobility & conductivity), Diffusion of charge carries and Life time of charge carries in a semiconductor. Work function in metals and semiconductors. Expressions for Barrier potential, Barrier width and Junction capacitance (diffusion & transition) for depletion layer in a PN junction. Expressions for Current (diode equation) and Dynamic resistance for PN junction.	9	CO1
2	**Transistor Modelling**	Transistor as Two-Port Network. Notation for dc & ac components of voltage & current. Quantitative discussion of Z, Y & h parameters and their equivalent two-generator model circuits. h-parameters for CB, CE & CC configurations. Analysis of transistor amplifier using the hybrid equivalent model and estimation of Input Impedance, Output Impedance and Gain (current, voltage & power).	8	CO2
3	**Field Effect Transistors**	**JFET:** Construction (N channel & P channel); Configuration (CS, CD & CG); Operation in different regions (Ohmic or Linear, Saturated or Active or Pinch off & Break down); Important Terms (Shorted Gate Drain Current, Pinch Off Voltage & Gate Source Cut-Off Voltage); Expression for Drain Current (Shockley equation); Characteristics (Drain & Transfer); Parameters (Drain Resistance, Mutual Conductance or Transconductance & Amplification Factor); Biasing w.r.t. CS configuration (Self Bias & Voltage Divider Bias); Amplifiers (CS & CD or Source Follower); Comparison (N & P channels and BJTs & JFETs). **MOSFET:** Construction and Working of DE-MOSFET (N channel & P channel) and E-MOSFET (N channel & P channel); Characteristics (Drain & Transfer) of DE-MOSFET and E-MOSFET; Comparison of JFFET and MOSFET.	8	CO3
4	**Other Devices**	**SCR:** Construction; Equivalent Circuits (Two Diodes, Two Transistors & One Diode-One Transistor); Working (Off state & On state); Characteristics; Applications (Static switch, Phase control system & Battery charger). **UJT:** Construction; Equivalent Circuit; Working (Cutoff, Negative Resistance & Saturation regions); Characteristics (Peak & Valley points); Applications (Trigger circuits, Relaxation oscillators & Sawtooth generators).	5	CO4
5	**Number System**	Number Systems: Binary, Octal, Decimal & Hexadecimal number systems and their inter conversion. Binary Codes: BCD, Excess-3 (XS3), Parity, Gray, ASCII & EBCDIC Codes and their advantages & disadvantages. Data representation.	6	CO5
6	**Binary Arithmetic**	Binary Addition, Decimal Subtraction using 9's & 10's complement, Binary Subtraction using 1's & 2's compliment, Multiplication and Division.	5	CO6
7	**Logic Gates**	Truth Table, Symbolic Representation and Properties of OR, AND, NOT, NOR, NAND, EX-OR & EX-NOR Gates. Implementation of OR, AND & NOT gates (realization using diodes & transistor). De Morgan's theorems. NOR & NAND gates as Universal Gates. Application of EX-OR & EX-NOR gates as pairty checker. Boolean Algebra. Karnaugh Map.	9	CO7
8	**Combinational and Sequential Circuits**	**Combinational Circuits:** Half Adder, Full Adder, Parallel Adder, Half Substractor, Full Substractor. Data **Processing Circuits:** Multiplexer, Demultiplexer, Decoders & Encoders. **Sequential Circuits:** SR, JK & D Flip-Flops, Shift Register (transfer operation of Flip-Flops), and Asynchronous & Synchronous counters.	10	CO8

Reference Books:

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

e-Learning Source:

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

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)										
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	**3**	**2**	-	-	-	-	**3**	**2**	-	**1**	**2**
CO2	**3**	**2**	-	-	-	-	**3**	**3**	-	**1**	**2**
CO3	**3**	**2**	-	-	-	-	**3**	**3**	-	**2**	**2**
CO4	**3**	**2**	-	-	-	-	**3**	**3**	-	**3**	**2**
CO5	**3**	**2**	-	-	-	-	**3**	**3**	-	**3**	**2**
CO6	**3**	**2**	-	-	-	-	**3**	**2**	-	**1**	**2**
CO7	**3**	**2**	-	-	-	-	**3**	**3**	-	**1**	**2**
CO8	**3**	**2**	-	-	-	-	**3**	**3**	-	**2**	**2**

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name and Sign of Program Coordinator	**Sign and Seal of HoD**

Integral University, Lucknow

Effective from Session: 2024-25							
Course Code	B010603P/PY316	**Title of the Course**	**Analog & Digital Circuits**	**L**	**T**	**P**	**C**
Year	**Third**	**Semester**	Sixth	**0**	**0**	**4**	**2**
Pre-Requisite	10+2 with Physics	**Co-requisite**	Passed B.Sc. 2nd Year				
Course Objectives	The purpose of this undergraduate course is to impart practical knowledge/measurements in Analog and Digital Electronics through different experiments related to its theoretical course.						

Course Outcomes	
CO1	To learn about the different methods of finding the energy band gap of a semiconductor.
CO2	To calculate the hybrid parameter of a transistor from normal parameters.
CO3	To study the behaviour of FET and MOSFET from their characteristic curves.
CO4	To study the behaviour of SCR and UJT from their characteristic curves.
CO5	To study the functioning the working of different logic gates.

*** A student has to perform at least 7 experiments from the Offline Experiment List and 3 from the Online Virtual Lab Experiment List / Link.**

Experiment No.	**Title of the Experiment**	**Aim of the Experiment (*Offline)**	**Contact Hrs.**	**Mapped CO**
1	Energy Band Gap	To find the energy band gap of semiconductor by reverse saturation current method.	4	CO1
2	Four Probe Method	To find the energy band gap of semiconductor by four probe method.	4	CO1
3	Hybrid parameters of transistor	To find the hybrid parameters (h – parameters) of a transistor in Common Emitter Mode	4	CO2
4	Field Effect Transistor (FET)	To study the characteristics of FET.	4	CO3
5	Metal Oxide Field Effect Transistor (MOSFET)	To study the characteristics of MOSFET.	4	CO3
6	Silicon Controlled Rectifier	To study the characteristics of SCR.	4	CO4
7	Unijunction Transistor	To study the characteristics of UJT.	4	CO4
8	Logic Gates	To study and verify the logics of: (i) AND gate using TTL IC 7408 (ii) OR gate using TTL IC 7432 (iii) NOT gate using TTL IC 7404 (iv) Ex-OR gate using TTL IC 7486 (v) NAND gate and use as Universal gate using TTL IC 7400 (vi) NOR gate and use as Universal gate using TTL IC 7402	4	CO5
Experiment No.	**Title of the Experiment**	**Aim of the Experiment (*Online Virtual Lab)**	**Contact Hrs.**	**Mapped CO**
1	Field Effect Transistor (FET)	I_D-V_D characteristics of Junction Field Effect Transistor (JFET)	--	--
2	Silicon Controlled Rectifier	Silicon Controlled Rectifier (SCR) characteristics	--	--
3	Unijunction Transistor	Unijunction Transistor (UJT) and relaxation oscillator	--	--
4	Logic Gates	Verification and interpretation of truth table for AND, OR, NOT, NAND, NOR, Ex-OR, Ex- NOR gates	--	--
5	Half Adder and Full Adder	Construction of half and full adder using XOR and NAND gates and verification of its operation	--	--
6	Half Subtractor and Full Subtractor	To study and verify half and full subtractor	--	--
7	Universal Gates	Realization of logic functions with the help of Universal Gates (NAND, NOR)	--	--
8	NOR Gate Latch	Construction of a NOR gate latch and verification of its operation	--	--
9	Flip Flops	Verify the truth table of RS, JK, T and D Flip Flops using NAND and NOR gates	--	--
10	Shift Registers	Design and verify the 4-Bit Serial In - Parallel Out Shift Registers	--	--
11	Decoder and Encoders	Implementation and verification of decoder or demultiplexer and encoder using logic gates	--	--
12	Multiplexer and Demultiplexer	Implementation of 4x1 multiplexer and 1x4 demultiplexer using logic gates	--	--
13	Synchronous and Asynchronous Counter	Design and verify the 4-Bit Synchronous or Asynchronous Counter using JK Flip Flop	--	--
14	Binary to Gray and Gray to Binary conversion	Verify Binary to Gray and Gray to Binary conversion using NAND gates only	--	--
15	1-Bit and 2-Bit comparator	Verify the truth table of 1-Bit and 2-Bit comparator using logic gates	--	--

Reference Books:

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

e-Learning Source:

1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74
2. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/index.php?sub=1&brch=281
3. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities.

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)										
PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4
CO1	2	---	---	---	---	---	3	3	---	---	3
CO2	2	---	---	---	---	---	3	3	---	---	3
CO3	3	---	---	---	---	---	2	3	---	---	3
CO4	2	---	---	---	---	---	3	3	---	---	3
CO5	3	---	---	---	---	---	2	3	---	2	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**