

Girijananda Chowdhury University, Assam

Course Structure

Two Year Post Graduate Programme in Physics (under NEP-2020)

Path 1: 2 years MSc (Coursework Only)

SUMMARISED COURSE STRUCTURE

Sem	DSC	DSE	OEC	SEC	Dissertation/ project/Internship	Credit	Exit option
I	16	-	4			20	2 years MSc (Coursework)
II	20	-	-	-		20	
III	8	8	-	4		20	
IV	8	10	-	-	2	20	

DSC: Disciplinary Core Course DSE: Disciplinary Elective Course SEC: Skill Enhancement Course

OEC: Open Elective Course

First Semester

Code	Course	Category of Course	L-T-P	Total Credit
MPY26414T	Mathematical Physics	DSC	3-1-0	4
MPY26415T	Classical Mechanics	DSC	3-1-0	4
MPY26416T	Quantum Mechanics	DSC	3-1-0	4
MPY26431T	Data Science and Machine Learning	OEC	3-1-0	4
MPY26417P	General Laboratory I	DSC	0-0-8	4
TOTAL				20

Second Semester

Code	Course	Category of Course	L-T-P	Total Credit
MPY26418T	Atomic and Molecular Physics	DSC	3-1-0	4
MPY26419T	Condensed Matter Physics	DSC	3-1-0	4
MPY26420T	Statistical Mechanics	DSC	3-1-0	4
MPY26421T	Nanomaterials	DSC	3-1-0	4
MPY26422P	General Laboratory-II	DSC	0-0-8	4
TOTAL				20

Third Semester				
Code	Course	Category of Course	L-T-P	Total Credit
MPY26501T	Electronics	DSC	3-1-0	4
MPY26561T	Workshop Practice(Physics)/ MOOC course on programming	SEC	0-0-8	4
MPY26502P	General Laboratory III	DSC	0-0-8	4
MPY26521T/ MPY26522T	DSE1:MaterialSynthesisCharacterisation/ Advanced Electronics	DSE	3-1-0	4
MPY26523T/ MPY26524T	DSE2: Thin Films Phenomena/ Network Analysis & Microwave Electronics	DSE	3-1-0	4
TOTAL				20

Fourth Semester				
Code	Course	Category of Course	L-T-P	Total Credit
MPY26503T	ElectromagneticTheoryand Electrodynamics	DSC	3-1-0	4
MPY26504T	Nuclear and Particle Physics	DSC	3-1-0	4
MPY26525T/ MPY26526T	Laser and Spectroscopy/ General Theory of Relativity & Cosmology	DSE	3-1-0	4
MPY26527T/ MPY26528T	Nonlinear Optics/ High Energy Physics	DSE	3-1-0	4
MPY26505R	Minor Project/ Internship	DSC	0-0-4	2
MPY26506P	General Laboratory IV	DSC	0-0-4	2
TOTAL				20

Path 2: 2 years MSc (Coursework + Research)

The first three semesters are same as Path 1

SUMMARISED COURSE STRUCTURE								
Sem	DSC	DSE	OEC	SEC	Internship	Dissertation/ project	Credit	Exit option
IV	8	-	-	-	-	12	20	2 years MSc (Coursework + Research)

Fourth Semester				
Code	Course	Category of Course	L-T-P	Total Credit
MPY26507T	Research Methodology	DSC	3-1-0	4
MPY26508P	Advanced Research Laboratory/ Use of MATLAB, Mathematica etc	DSC	0-0-8	4
MPY26509R	Dissertation	DSC	0-0-24	12
TOTAL				20

Path 3: 2 years MSc (Research)

The first three semesters are same as Path 1

SUMMARISED COURSE STRUCTURE								
Sem	DSC	DSE	OEC	SEC	Internship	Dissertation/ project	Credit	Exit option
IV	4	-	-	-	-	16	20	2 years MSc (Research)

Fourth Semester				
Code	Course	Category of Course	L-T-P	Total Credit
MPY26507T	Research Methodology	DSC	3-1-0	4
MPY26510R	Research Project II(Full Dissertation)	DSC	0-0-32	16
TOTAL				20

One Year Post Graduate Programme in Physics (under NEP-2020)

SUMMARISED COURSE STRUCTURE								
Path	Sem	DSC	DSE	SEC	Internship	Dissertation/ project	Credit	Exit option
1 year MSc (Coursework Only)	I	8	8	4	-	-	20	1 year MSc (Coursework)
	II	8	8	-	2	2	20	
1 year MSc (Coursework + Research)	I	8	8	4	-	-	20	1 year MSc (Coursework + Research)
	II	4	-	-	-	16	20	
1 year MSc (Research Only)	I	4	-	-	-	16	20	1 year MSc (Research)
	II	-	-	-	-	20	20	

Path1: One Year MSc (Coursework Only)

YEAR – 1

First Semester				
Code	Course	Category of Course	L-T-P	Total Credit
MPY26511T	Condensed Matter Physics	DSC	3-1-0	4
MPY26561P	Workshop Practice(Physics)/ MOOC course on programming	SEC	0-0-8	4
MPY26512P	PG General Laboratory	DSC	0-0-8	4
MPY26521T/ MPY26522T	DSE1:MaterialSynthesisCharacterisation/ Advanced Electronics	DSE	3-1-0	4
MPY26525T/ MPY26526T	DSE2: Laser & Spectroscopy/ General Theory of Relativity &Cosmology	DSE	3-1-0	4
TOTAL				20

Second Semester				
Code	Course	Category of Course	L-T-P	Total Credit
MPY26503T	ElectromagneticTheoryand Electrodynamics	DSC	3-1-0	4
MPY26504T	Nuclear and Particle Physics	DSC	3-1-0	4
MPY26523T/	Thin Film Phenomena/	DSE	3-1-0	4

MPY26524T	Network Analysis & Microwave Electronics			
MPY26527T/ MPY26528T	Nonlinear Optics/ High Energy Physics	DSE	3-1-0	4
MPY26513R	Project/Dissertation	DSC	0-0-4	2
MPY26514R	Internship	DSC	0-0-4	2
TOTAL				20

Path 2: One Year MSc (Coursework + Research)

Semester I: Same as MSc (Coursework Only)

Second Semester				
Code	Course	Category of Course	L-T-P	Total Credit
MPY26507T	Research Methodology	DSC	3-1-0	4
MPY26515R	Extended Dissertation	DSC	0-0-32	16
TOTAL				20

Path 3: One Year MSc (Research Only)

First Semester				
Code	Course	Category of Course	L-T-P	Total Credit
MPY26507T	Research Methodology	DSC	3-1-0	4
MPY26516R	Research Project I	DSC	0-0-32	16
TOTAL				20

Second Semester				
Code	Course	Category of Course	L-T-P	Total Credit
MPY26517R	Research Project II	DSC	0-0-40	20
TOTAL				20

DETAILED SYLLABI

DSC	MATHEMATICAL PHYSICS	L	T	P	C
		3	1	0	4
Pre-requisite: Graduation level Mathematics and Physics					
Course Objectives:					
1. To provide fundamental knowledge of complex variables. 2. To enable students to learn different properties of Fourier and Laplace Transforms. 3. To make students familiar with elementary probability theory and the fundamentals of group theory. 4. To provide knowledge about tensors and their applications. 5. To provide knowledge about special functions used in Physics.					
Course Outcome:					
After successful completion of the course, the students will be able to					
CO 1: Remember the properties of special functions.					
CO 2: Understand the fundamentals of complex variables, Fourier and Laplace transforms, Probability theory, Group theory and special functions.					
CO 3: Apply the knowledge of complex variables, probability theory, Fourier and Laplace transform to solve simple problems.					
CO 4: Analyze the properties of Tensors and their applications in different areas of Physics.					
Module 1: COMPLEX VARIABLES				15 Hours	
Analytical Functions, Cauchy-Riemann Conditions, Cauchy’s Integral Theorem, Cauchy’s Integral formula, Taylor and Laurent’s series expansion, Cauchy’s Residue Theorem, Simple examples of contour integration					
Module 2: FOURIER AND LAPLACE TRANSFORMS				8 hours	
Fourier Transform, Convolution Theorem, Laplace Transforms, Laplace Transforms of derivatives, Substitution properties of Laplace Transform, Properties of gamma and beta functions, Error function and Dirac Delta functions.					
Module 3: PROBABILITY AND GROUP THEORY				11 hours	
Elementary Probability Theory, Random Variables, Binomial, Poisson and Normal Distributions, Central Limit Theorem, Central difference formula, Iterative process, Newton-Raphson formula, Introductory Group Theory					
Module 4: TENSORS				15 hours	
Contravariant and Covariant Tensor, Jacobian, Relative Tensor, Pseudo Tensors (Example: charge density, angular momentum), Riemann space (Example: Euclidean space and 4D Minkowski space), Christoffel Symbols, Transformation of Christoffel symbols, Covariant differentiation, Ricci’s theorem, Divergence, Curl and Laplacian tensor form, stress and strain tensor, Hooke’s Law in tensor form					
Module 5: SPECIAL FUNCTONS				11 hours	
Series solution of differential equations with variable coefficients, Legendre, Hermite, Laguerre, Associated Laguerre polynomials, Bessel functions and their generating functions, Recurrence relations, Orthogonal Properties and Rodrigue’s formula					
Textbook(s)					
1.	Mathematical Methods for Physicists, G.B. Arkfen, H.J. Weber, F.E, Harris, 2013, 7 th edition, Elsevier				
2.	Complex Variable (Schaum’s Outlines), Murray Spiegel, Seymour Lipschutz, John Schiller, Dennis Spellman, Revised 2 nd edition, McGraw Hill Education				
Reference Books					
1.	Advanced Engineering Mathematics, E. Kreyszig (2 nd edition, Pearson, 2002)				
2.	Mathematical Physics, B.D. Gupta, Vikas Publication House, 1986				
3.	Mathematical Physics, A.K. Ghatak, I.C. Goyal, S.J.Chua, Laxmi Publications Private Limited, 2016				
4.	Mathematical Methods, M.C. Potter and J. Goldberg, Prentice-Hall (2 nd edition, 1987)				

DSC	CLASSICAL MECHANICS	L	T	P	C
		3	1	0	4
Pre-requisite: Classical Mechanics of BSc Physics					
Course Objective					
(1) aims to understand the concepts of generalized coordinates and its subsequent applications to Lagrangian and Hamiltonian dynamics.					
(2) to be familiar with Hamiltonian dynamics and its applications to solve complex problems in a simplified manner.					
(3) enhance the knowledge regarding motion of the bodies under central force.					
(4) to have a broader perspective of rigid body kinematics in terms of mathematical analysis.					
(5) to enhance the knowledge of canonical transformation theory.					
Course Outcome:					
After successful completion of the course, the students will be able					
CO1: to remember the concepts of generalized coordinates, Hamiltonian dynamics, central force, rigid body dynamics and canonical transformation theory. and its subsequent applications to Lagrangian and Hamiltonian dynamics.					
CO 2: to understand different theories which explains the dynamics of systems.					
CO 3: to apply the concepts of Lagrangian and Hamiltonian dynamics to solve complex problems.					
CO 4: to analyze various parameters involved in the classical dynamics theory in various problems.					
Module 1: Lagrangian Dynamics					10 hours
Lagrangian Dynamics: Constraints, Generalized coordinates, Concept of virtual work, D'Alembert principle, Lagrange equation from D'Alembert principle, Velocity dependent potential, Expression for kinetic energy of a system in terms of Generalized coordinates, Cyclic coordinates, Symmetry properties and conservation theorems.					
Module 2: Hamiltonian Dynamics					12 hours
Hamiltonian dynamics: Hamiltonian function H and conservation of energy: Jacobi's integral and its significance, Hamilton's equation, Routhian, Hamiltonian, Variation principle, Derivation of Lagrange equation, Extension of Hamilton's Principle, on non-holonomic system, A hoop rolling without slipping on an inclined plane, Modified Hamilton's Variation principle, Derivation of Hamilton's equation from variation principle, Δ - variations, Principle of least actions in various forms, Introduction to Nonlinear Dynamical Theory and Chaos.					
Module 3: Motion under Central Force					14 hours
The Two Body Central Force Problem: Central force and motion in a plane, Reduction of a two body central force to equivalent one body problem, Equation of motion and first integral, Differential equation for an orbit, Equivalent one dimensional problem and classification of orbits for some specific potential, Integral power law potential, Virial theorem, Relation between kinetic and potential energy, Kepler's Problems: Equation of orbit and the kind of the orbit, Motion in time.					
Module 4: Rigid body kinematics					12 hours
The kinematics of rigid body motion: Independent co-ordinate of a rigid body, Orthogonal transformation, Formal properties of transformation matrix, Euler angles, Euler's theorem, Finite rotation, Infinitesimal rotations (contact transformation), Angular momentum, Moment of inertia tensor, Product of inertia, Inertia tensor, Principal moment of inertia: Principal axis, Kinetic energy of motion of a rigid body about a point, Normal modes.					
Module 5: Canonical transformation theory					12 hours
Canonical transformation and Hamilton Jacobi theory: Canonical transformation, Legendre transformation, Generating functions, Conditions for canonical transformation, Bilinear invariant Condition, Poisson's brackets, Lagrange brackets, Invariance of Poisson bracket under canonical transformation, Angular momentum Poisson bracket relation, Hamilton Jacobi equation for Hamilton's principal function, Harmonic oscillator problem by Hamilton, Jacobi method, Hamilton's characteristic function.					
Total Lecture hours					60 hours
Textbook(s)					

1.	H. Goldstein: Classical Mechanics, Narosa Publishing House, 2001
2.	Jonh R Taylor, Classical Mechanics, University Science Books, U.S, 2004
3.	David Morin, Introduction to Classical Mechanics, Cambridge University Press, 2009
4.	Murray Spiegel: Theoretical Mechanics, McGraw Hill Education, 2017.
5.	Frederick W. Byron and Robert W. Fuller: Mathematics of classical and Quantum Physics, Dover Publications; Revised ed. Edition,1992.
6.	Steven H. Strogatz: Nonlinear Dynamics and Chaos: With Applications in Physics, Biology, Chemistry, and Engineering, CRC Press, 2015.
Reference Books	
1.	N. C. Rana and P. S. Joag: <i>Classical Mechanics</i> , Tata Mc-Graw Hill, New Delhi, 1991.
2.	S. L. Gupta, V. Kumar, H. V. Sharma: <i>Classical Mechanics</i> , Pragati Prakashan, Meerut, 2009.
3.	P. V. Panat: <i>Classical Mechanics</i> , Narosa Publishing House, 2000.

DSC	QUANTUM MECHANICS	L	T	P	C
		3	1	0	4
Pre-requisite: Graduation Level Physics and Mathematics					
Course Objectives:					
To provide knowledge of the formalism of Quantum Mechanics To enable students to learn different aspects of Quantum Dynamics. To make students familiar with angular momentum algebra To provide knowledge about approximation methods in Quantum Mechanics. To provide knowledge about Scattering and Relativistic Quantum Mechanics.					
Course Outcome:					
After successful completion of the course, the students will be able to CO1: Remember the basic formalism of Quantum Mechanics, Quantum Dynamics, Angular Momentum, Angular Momentum, Approximation Methods, Scattering and Relativistic Quantum Mechanics. CO 2: Understand different aspects of angular momentum algebra for applications. CO 3: Apply the knowledge of Quantum Mechanics to solve simple problems. CO 4: Analyze Quantum Mechanical problems using approximation methods.					
Module 1:GENERAL FORMALISM OF QUANTUM MECHANICS					15 hours
Mathematical properties of linear vector spaces, Dirac's Bra and Ket notation, Inner product, norm of a vector, orthonormality and linear independence, Basis and dimension, Outer product, projection operator, completeness, closure property, Hermitian operators, eigenvalues and eigenvectors, postulates of Quantum Mechanics, wavefunction, probability density, orthogonality criterion, Representation Theory, change of basis, Unitary operator, matrix representation of operators, position and momentum representations, Expectation values, uncertainty relation, Ehrenfest Theorem, Schrodinger time independent and time dependent formulation.					
Module 2: QUANTUM DYNAMICS					12 hours
Gaussian Wave Packet, Schrodinger picture, Heisenberg picture, solution of simple harmonic oscillator problem by the operator method, symmetry and conservation laws, symmetries in Quantum Mechanics – hydrogen atom and spherical harmonics, spatial translation, time translation, parity, time reversal, Density matrices					
Module 3: ANGULAR MOMENTUM					10 hours
Orbital Angular Momentum, angular momentum algebra, spin, Ladder operators and their matrix representations, spin angular momenta and Pauli matrices, symmetric and anti-symmetric wavefunctions, Pauli's Exclusion Principle, spin and statistics, addition of angular momenta, Clebsch-Gordan coefficients					
Module 4: APPROXIMATION METHODS					10 hours
Time Independent Perturbation Theory, Variational Theory, WKB Method and their applications, Time dependent Perturbation Theory, transition to a continuum of final states – Fermi's Golden Rule, applications to constant and harmonic perturbations, sudden and adiabatic approximations.					
Module 5: SCATTERING AND RELATIVISTIC QUANTUM MECHANICS					13 hours
Scattering: The scattering experiments, relationship of cross-section and wave function, scattering					

amplitude, phase shifts, partial wave analysis, Born Approximation and applications. Relativistic Quantum Mechanics: Klien-Gordon and Dirac equations, Semi-classical theory of radiation – Einstein coefficients, atom field interaction, dipole matrix elements, spontaneous and stimulated emission rates, Selection Rules.	
Total Lecture hours	60 hours
Text Book(s)	
1.	Quantum Mechanics : Theory and Application, A. Ghatak and S. Loknathan, 4 th edition, Macmillan, 1999
2.	Modern Quantum Mechanics, J.J. Sakurai (Addison-Wesley, 1993)
Reference Books	
1.	Quantum Mechanics, L.I. Schiff, 3 rd edition, Mc-Graw Hill, 1968
2.	Introduction to Quantum Mechanics, D.J. Griffith, 2 nd Edition, Pearson Education, 2005
3.	Quantum Physics, S. Gasiorowicz, Wiley (3 rd edition, 2003)

OEC	DATA SCIENCE AND MACHINE LEARNING	L	T	P	C
		3	1	0	4
Pre-requisite: Calculus, Statistics and Linear Algebra					
Course Objectives:					
1. To impart to the students a comprehensive course on the basics and applications of Data Science and Machine Learning. 2. To disseminate lectures on classification and regression models and also to teach the challenges of deploying these models in real-world datasets. 3. To evaluate the working principles between Neural Networks and its implication in both classification and regression models.					
Course Outcome:					
At the end of a course, a student is able to: CO 1: to remember the basics of statistics and apply the tools in data science. CO 2: to understand the suitable machine learning algorithm taking into consideration the features of the given dataset. CO 3: to apply machine learning models appropriately in any dataset, with the additional knowledge and skill of handling missing data, dimensionality reduction and undersampling/oversampling. CO 4: to analyze the appropriate Neural Networks in diverse areas such as Image Recognition, Pattern Recognition, Classification, Trend Analysis, Time-Series anomaly detection and Prediction and so on.					
Module 1: Basics of Statistics and Machine Learning					5 Hours
Statistical Distributions – Binomial, Poisson and Gaussian Distribution, Moments – Mean, Variance, Skew and Kurtosis, Central Limit Theorem, Covariance and Correlation, Bayes' Theorem.					
Module 2: Regression and Classification Models					25 hours
Linear and Polynomial Regression, Logistic Regression, Support Vector Machine, K-Nearest Neighbors, Decision Tree and Naïve Bayes, K-Means Clustering, Recommendation Systems – Cosine Similarity, Reinforcement Learning. Entropy, Overfitting and Underfitting, Confusion Matrix in Classification Models – Accuracy, Precision, Sensitivity, Recall and F1 Score. Challenges of Real-World Datasets - Bias-Variance Trade-Off, Detection of Outliers, Feature Engineering and the Curse of Dimensionality, Dimensionality Reduction – Principal Component Analysis (PCA), Imputation Techniques for Missing Data, Undersampling and Oversampling in Unbalanced Datasets. Activity -Mammogram, PIMA (Indian Diabetes) and Spam/Ham Detection.					
Module 3: Deep Learning and Neural Networks					15 hours
Prerequisites of Deep Learning, Basics of TensorFlow and Keras, Recurrent Neural Network (RNN), Convolutional Neural Network (CNN), LSTM (Long Short-Term Memory), Time Series Prediction and Image Classification, Tuning Neural Networks: Training Rate and Batch Size Hyperparameters, Regularization with Dropout and Early Stopping. Activity -Prediction of Political Affiliation, Image Recognition and Chaotic Time-Series Prediction.					
Textbook (s)					
1.	Practical Statistics for Data Scientists: 50+ Essential Concepts Using R and Python, 2nd Edition, P.				

2.	Bruce, A. Bruce and P. Gedeck (2020).
3.	Hands-On Machine Learning with Scikit-Learn, Keras and TensorFlow, 2 nd Edition, A. Green (2019).
	Data Science From Scratch: First Principles with Python (O'Reilly), 2 nd Edition, J. Grus (2019).
Reference Books	
1.	The Art of Statistics: Learning from Data (Pelican Books), David Spiegelhalter (2020).
2.	Introducing Data Science: Big Data, Machine Learning, and More, Using Python Tools (Dreamtech Press), D. Cielen, A.D.B. Meysman and M. Ali (2016)

DSC	GENERAL LABORATORY - I	L	T	P	C
		0	0	8	4
Pre-requisite: Basic Computer Skills.					
Course Objectives:					
Course Objective : 1) To gain a broad perspective about the uses of computers in engineering industry. . 2) To develop basic understanding of computers, the concept of algorithm and algorithmic thinking. 3) To improve the ability to incorporate exception handling in object-oriented programs. 4) To develop the use of the C programming language to implement various algorithms and develops the basic concepts and terminology of programming in general.					
Course Outcome:					
After successful completion of the course, the students will be able CO1: To learn the basic knowledge in fundamentals of programming, algorithms and programming technologies and fundamentals of Computer Science. CO2: To understand the basic idea of how to control the sequence of a program and give logical output. CO3: To Develop C programs to solve simple engineering problems using looping constructs. 4: To apply the concept of Strings for writing programs related to character array.					
List of Experiments:					
1) Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c input and c output a) Write a program to display a string of alphabets ex: Hello World. b) Write a program to take two values using standard input function and find: a) Addition of two values. b) Subtraction of a value from another value. c) Multiplication of two values. d) Division between two values. e) Modulo division between two values. f) Write a program to read a character in upper case and then print in lower case g) Write a program to convert degrees Fahrenheit into degrees Celsius. h) Write a program to calculate the bill amount for an item given its quantity sold, value, discount and tax display the result using standard output function. 2) Programs using simple control statements such as if-else, while, do-while, for loop etc. a) Write a program to find whether the given number is even or odd. b) Write a program to find whether a given year is a leap year or not. c) Write a program to calculate the root of a quadratic equation. d) Write a program to display the sin(x) value where x ranges from 0 to 360 in steps of 15. e) Write a program to determine whether an entered character is a vowel or not by using switch case statement. f) Write a program to calculate the average of numbers entered by the user using while statement. g) Write a program using do-while loop to display the square and cube of first n natural numbers.					

- h) Write a program to calculate X^n by using for loop.
- i) Write a program to calculate sum of squares of first n even numbers.
- j) Write a program that accepts any number and prints the number of digits in that number.
- k) Write a program to enter hexadecimal number and display the decimal equivalent of this number.
- l) Write a program to calculate square root of a number by using break and continue statement.
- 3) Programs using Arrays: declaring and initializing arrays. Program to do simple operations with arrays Strings – inputting and outputting strings. Using string functions such as strcat, strlen
 - a) Write a program to read and display n numbers using an array.
 - b) Write a program to arrange the elements of an array in ascending order.
 - c) Write a program to interchange the largest and the smallest number in the array.
 - d) Write a program to delete number from an array that is already sorted in ascending order.
 - e) Write a program to merge two unsorted arrays Write a program to implement linear search.
 - f) Write a program to print the elements of a 2D array.
 - g) Write a program to read and print the elements of a matrix.
 - h) Write a program to find the sum of two same order matrices and print the sum matrix.
 - i) To find the product of two matrices and print the product matrix.
- 4) Use of strings :
 - a) Write a program to input and display a string.
 - b) Write a program to concatenate two strings taken as input using standard input function and display.
 - c) Write a program to find if a string is palindrome or not.
 - d) Write a program to reverse a string.
- 5) Write a program (by using function) :
 - a) Sum of two numbers.
 - b) Subtraction of a value from another value.
 - c) Multiplication of two values.
 - d) Division between two values.
- 6) Solve the s-wave Schrodinger equation for the ground state and the first excited state of the Hydrogen atom:

$$\frac{d^2 Z}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2} [V(r) - E], \text{ where } V(r) = -\frac{e^2}{r}$$

Here, m is the reduced mass of the electron. Obtain the energy Eigenvalues and plot the corresponding wave functions. Remember that the ground state energy of the hydrogen atom is -13.6 eV Take $e = 3.795 \text{ (eV}\text{\AA})^{1/2}$, $\hbar c = 1973 \text{ (eV}\text{\AA})$ and $m = 0.511 \times 10^6 \text{ eV}$.

Textbook(s)	
1.	PROGRAMMING IN ANSI C BY E. BALGURUSWAMY, TATA MC-GRAW HILL.
2.	PROGRAMMING WITH C, SCHAUM SERIES.
3.	A FIRST COURSE IN PROGRAMMING WITH C, T. JEYAPOOVAN, VIKASH PUBLISHING HOUSE PVT. LTD.
4.	COMPUTER FUNDAMENTALS AND PROGRAMMING IN C, REEMA TAHREJA, OXFORD HIGHER EDUCATION

DSC	ATOMIC AND MOLECULAR PHYSICS	L	T	P	C
		3	1	0	4
Pre-requisite: Quantum Mechanics.					
Course Objectives:					
1. To impart a comprehensive course on the applications of Quantum Mechanics in the Physics of Atoms and Molecules.					
2. To disseminate lectures on the Molecular Physics of Diatomic Molecules.					
3. To evaluate the connection behind spectroscopic methods such as Raman Effect, Electron Spin Resonance (ESR) and Nuclear Magnetic Resonance (NMR) and Molecular Physics.					
4. To teach students the physics behind the operation of Lasers and the properties associated with it.					
Course Outcome:					
After successful completion of the course, the students will be able					
CO 1: to remember the operating principles of Laser, the properties and the numerous types of Lasers.					
CO 2: to understand the application of Perturbation Theory in the Fine Structure of Hydrogen and spectroscopic methods such as Zeeman and Stark Effect.					
CO 3: to apply the physics behind the Rotational, Vibrational and Electronic structure of Diatomic Molecules.					
CO 3: to analyze the physics of various spectroscopic methods such as Raman Effect, ESR and NMR based on the lectures of Molecular Physics.					
Module 1: Atomic Physics					20 Hours
Fine Structure of One-Electron Atoms – Mass Correction, Spin-Orbit and Darwin Terms, Effect of Electric and Magnetic Fields: Zeeman, Paschen-Bach and Stark Effects, Ground State of Two-Electron Atoms – Perturbation Theory and Variational Methods, LS and JJ Coupling, Lande Interval and Selection Rules, Collision and Doppler Broadening.					
Module 2: Molecular Physics - I					10 hours
Born-Oppenheimer approximation for diatomic molecules, Rotational, Vibration and Electronic Structure of Diatomic Molecules, Spectroscopic terms, Electronic Structure - Molecular Symmetry and the States, Molecular Orbital and Valence Bond Methods for Hydrogen molecule and ion.					
Module 3: Molecular Physics - II					15 hours
Rotational Spectra of Diatomic Molecules, Isotope Effect, Vibrational Spectra of Diatomic Molecules - Harmonic and Anharmonic Vibrators, Vibration-Rotation Spectra, Electronic Spectra of Diatomic Molecules - Vibrational Structure of Electronic Transitions, Rotational Structure of Electronic Bands - P, Q, R branches, Fortrat diagram, Franck-Condon principle, Electron Spin and Hund's cases, Raman Effect, ESR and NMR.					
Module 4: Lasers					15 hours
Operating Principle of Laser –Threshold Condition for Laser Oscillation, Rabi frequency, Laser Pumping, Population Inversion and Resonator Modes, Multilevel rate equations and saturation, Laser Properties and Profile of Spectral Lines, Types of Lasers - He-Ne, CO2 and Semiconductor.					
Textbook(s)					
1.	Physics of Atoms and Molecules (2nd edition Pearson, January 2003), B. H. Bransden and C. J. Joachain.				
2.	Molecular Structure and Spectroscopy (Prentice Hall India, January 2007), G. Aruldas.				
3.	Optical Electronics (Cambridge India, January 2017), Ajoy Ghatak and K. Thyagarajan.				
Reference Books					
1.	Principles of Quantum Mechanics (Cambridge University Press, August 2016), David J. Griffiths.				
2.	Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles (2nd Paperback Wiley, January 2006), R. Resnick and R. Eisberg.				
3.	Fundamentals of Molecular Spectroscopy (Tata McGraw Hill, June 2001), C. Banwell and E. McCash.				

DSC	CONDENSED MATTER PHYSICS	L	T	P	C
		3	1	0	4
Pre-requisite:BSc course on Condensed Matter Physics					
Course Objective					
(1) aims to enhance the concepts of crystalline nature of solids with a complete knowledge of vibrations in the crystal through proper mathematical analysis.					
(2) to be familiar with different types of crystals in detailed manner understanding their electric nature.					
(3) enhance the knowledge regarding ferromagnetic with the help of different theories.					
(4) to have a broader perspective of superconductors and their properties via varied equations					
(5) to enhance the knowledge of band theory of solids.					
Course Outcome:					
After successful completion of the course, the students will be able					
CO1: To remember the nature of crystalline solids.					
CO 2: To understand the theory of ferroelectric transitions, the dynamics, thermodynamics and phase transition.					
CO 3: To apply various theories to have a broader knowledge of ferromagnetic.					
CO 4: To analyze the properties of superconductors with the results provided by various mathematical theories.					
Module 1: Crystalline solids				15 hours	
Fundamentals of crystal structure, Diffraction of waves by crystals, Reciprocal lattice and its application to diffraction Technique, Laue, Powder and rotating crystal method, Crystal structure factor and atomic form factor, Lattice Vibrations: Quantization of elastic waves, Phonon momentum and inelastic scattering by phonons.					
Defects in Crystal: Point defects, Colour centres, F-centres, Line defects and planer defects, Role of dislocations in crystal growth					
Module 2: Ferroelectrics				10 hours	
Ferroelectrics: Classification of ferroelectric crystals, Theory of the ferroelectric displacive transitions:Polarization catastrophe, Soft optical phonon, Thermodynamics of ferroelectric transition, Ferroelectric domains, Antiferroelectric, Piezoelectric and pyroelectric material.Phase Transition: First and second order transition, Long range order, Short range order and Bragg William model.					
Module 3: Ferromagnetism				10 hours	
Weiss theory of ferromagnetism, Exchange interaction: Heisenberg model, Ferromagnetic domains, Origin of domains, Anisotropy energy, Bloch wall, Curie-Weiss law for susceptibility, Antiferromagnetic, Ferrimagnetic order, Spin wave and magnons.					
Module 4: Superconductivity				10 hours	
Basic phenomena, Meissner effect, Critical field, Type- I and Type- II superconductors, Heat capacity, Isotope effect, London equations, Coherence length, BCS theory of superconductivity, Flux quantization, Normal tunneling, dc and ac Josephson Effect, SQUID, High temperature superconductors.					
Module 5: Band Theory of Solids				15 hours	
Band Theory of Solids: Electrons in periodic lattice, Bloch theorem, Nearly free electron model, Tight binding approximation, Fermi surface, de Hass-Van Alphen effect, Cyclotron resonance, Magnetoresistance, Quantum Hall effect.Optical Properties: Refractive index, Electronic polarization, Optical absorption, Photoconductivity, Relationship between absorption coefficient and band gap recombination.					
Total Lecture hours				60 hours	
Text Book(s)					
1.	C. Kittel: Introduction of Solid State Physics, 7 th edition, John Wiley & Sons, 2004.				
2	A.J. Dekker: Solid State Physics, Prentice Hall, 1957.				
3	N.W. Ashcroft N.D. Mermin: Solid State Physics, Holt, Rinehart and Winston, 1976.				
4	J.M Ziman: Principles of the theory of Solids, Cambridge University Press, 2000.				
5	Nicola Spaldin, Magnetic Materials,				
Reference Books					

1.	J.P. Shrivastava: Elements of Solid State Physics, 2 nd edition, PHI, New Delhi, 2006.
2.	L.V. Azaroff: Introduction to Solids, TMH edition, 1996.
3.	M. Tinkham: Introduction to superconductivity, Dover Publications, 2004.

DSC	STATISTICAL MECHANICS	L	T	P	C
		3	1	0	4
Pre-requisite: Graduation Level Physics					
Course Objectives:					
(1) To provide fundamental knowledge about Statistical Mechanics for describing systems containing large number of particles.					
(2) To introduce the advance concepts of Classical Statistical Mechanics so that students will be equipped with sufficient knowledge of the subject.					
(3) To impart fundamental knowledge of Quantum Statistical Mechanics and its applications.					
(4) To develop the interest and ability among students to solve challenging physical problems by the application of techniques of Statistical Mechanics in future.					
Course Outcome:					
After successful completion of the course, it is expected that the students will be able to					
CO1: Remember the Statistical Laws for all physical phenomena.					
CO2: Understand and appreciate different features of Quantum Statistical Mechanics so as to gain insight into diverse physical phenomena.					
CO3: Apply different aspects of Classical Statistical Mechanics.					
CO4: Analyze the universality of critical exponents characterizing phase transitions.					
Module 1:Review of thermodynamics and topics in probability theory					10 hours
Statistical basis of thermodynamics, probability concepts, entropy of a probability distribution, random walk, microstate and macrostate, phase space, Liouville theorem					
Module 2: Classical statistical mechanics					19 hours
Concept of ensembles, microcanonical, canonical and grand canonical ensembles, system in grand canonical ensembles, Partition functions, principle of equipartition of energy.					
Energy of Harmonic oscillator, partition function for canonical ensemble, energy fluctuations in the canonical ensemble, partition function and Thermodynamic function for grand canonical ensemble, density fluctuations in the grand canonical ensemble, theory of paramagnetism, negative temperature.					
Module 3: Quantum statistical mechanics					15 hours
Indistinguishable particles in quantum mechanics, Bosons and Fermions, Bose-Einstein statistics, ideal Bose gas, photons, Bose-Einstein condensation. Fermi-Dirac statistics, Fermi energy, ideal Fermi gas, Density operator, Quantum Liouville equation, pure and mixed states.					
Module 4: Fluctuations and phase transitions					16 hours
Brownian motion; diffusion equation, approach to equilibrium: the Fokker –Planck equation, introduction to non-equilibrium processes					
First and second order phase transition,phase diagram,Interacting spin systems, the Ising model (one dimension), paramagnetic and ferromagnetic phases, liquid helium					
Total Lecture hours					60 hours
Text Book(s)					
1.	Statistical Mechanics, R.K. Pathria (Butterworth-Heinemann, Second Edn, 1996).				
2.	Statistical Mechanics, K. Huang (2ndEdition, Wiley-India, 2008).				
3.	Statistical Physics : L. Landau and E.M. LifShitz.				
Reference Books					
1.	Statistical Mechanics: An Advanced course with problems and solutions, Ryogo Kubo (North-Holland, 1965)				
2.	Statistical Physics : F. Reif				

DSC	NANOMATERIALS	L	T	P	C
		3	1	0	4
Pre-requisite: Graduation Level Physics					
Course Objectives:					
(1) To provide fundamental knowledge about nanomaterials					
(2) To enable students to learn different methods of fabrication and characterization of nano structured materials.					
(3) To make students familiar with specific features of nanoscale growth and thermodynamics.					
(4) To learn about the remarkable properties of nanomaterials.					
(5) To provide knowledge about application of nanomaterials.					
Course Outcome:					
After successful completion of the course, the students will be able to					
CO1: Remember physics at the nanoscale.					
CO 2: Understand different methods of synthesis and characterization of nanomaterials.					
CO 3: Apply properties of materials at the nanoscale in emerging areas.					
CO 4: Analyse the properties specific to nanomaterials.					
Module 1: INTRODUCTION					10 hours
Nano size scale, History of Nanotechnology, Quantum Mechanics and Fluctuation in nanostructure systems, surface area to volume ratio, surface energy, chemical potential as a function of surface curvature, Electronic stabilization and steric stabilization, Idea of zero, one and two dimension structures, vacancies and dislocations in nanocrystals, Effect of nanoscale dimensions on various properties.					
Module 2: SYNTHESIS AND CHARACTERIZATION					19 hours
Synthesis: Top-down and bottom-up approaches, synthesis of metal, semiconductor, carbon and bio nanomaterials, Grains and grain boundaries, distribution of grain sizes, pores, strains. Thin film preparation methods by thermal evaporation, sputtering and pulsed laser deposition methods. Gas phase synthesis of nanopowders, chemical and colloidal methods, mechanical milling, dispersion in solid-doped glasses and sol gel method, functionalization of nanoparticles. Characterization: Characterization by diffraction method and optical methods. Chemical characterizations- Raman spectroscopy, XPS, XAS and EXAFS.					
Module 3: STRUCTURE AND THERMODYNAMICS AT NANOSCALE					9 hours
Specific features of the nanoscale growth control of size, nucleation, growth and aggregation. Crystalline phase transitions and geometric evolution of the lattice in nano crystals, thermodynamics of very small systems. Self-assembling nanostructured molecular materials and devices.					
Module 4: PROPERTIES					11 hours
Melting point and lattice constants, Mechanical properties, Optical properties; Surface Plasmon effect, Quantum size effect, Electrical conductivity; Surface Scattering, Change of Electronic structure, Quantum Transport, Effect of microstructure, Ferroelectric and dielectrics, Superparamagnetism.					
Module 5: APPLICATIONS					
Application in molecular and nano-electronics, Biological applications (imaging, drug delivery), Quantum well and quantum dot devices, Energy application of nanomaterials; Photochemical cell, Lithium –ion battery, Hydrogen storage and thermo-electrics, Environmental application, Photonic crystals.					
Textbook(s)					
1.	Nanostructures and Nanomaterials: Synthesis, Properties and Applications - Guozhong Cao and Ying Wang, 2nd Ed., World Scientific, Singapore, 2011.				
2.	Introduction to Nanoscience - S.M. Lindsay, Oxford University Press, New York, 2010.				
3.	Introduction to Nanotechnology, C. P. Poole Jr. & F. J. Owens (Wiley-Interscience, 2003)				
Reference Books					
1.	Nanoscience and Nanotechnology - B.K. Parthasarthy (Edited), Isha Books, Delhi, 2007.				
2.	Nanostructured Materials and Nano Technology, H. S. Nalwa (Ed.) (Academic Press, 2002)				

DSC	General Laboratory-II	L	T	P	C
		0	0	8	4
Prerequisite : Graduate level Laboratory knowledge					
Course Objective :					
This course aims at performing basic physics experiments by the students. The students will be able to determine					
1. Some physical parameters and design circuits to understand important principles of Physics.					
2. Enable the students to analyze problems starting from first principles, evaluate and validate experimental results, and draw logical conclusions thereof.					
3. Make the students to understand that acquiring knowledge and skills appropriate to their professional activities is a never-ending process.					
4. This lab will help the students to understand and Introducing basic concepts via diffraction methods, lattice vibrations and free electrons, Hall Effect.					
5. Enhance the knowledge of students to the band structures for studying different materials.					
Course Outcome:					
CO1: Students will gain in-depth knowledge about the molecular structure using various concepts.					
CO2: To understand the basic idea of different types of preparation methods of nanomaterial's and their characterization techniques and interpretations.					
CO3: Students will be able to answer about various spectroscopic techniques and their modern developments.					
CO4: To increase the level of understanding of students about the various spectra of atoms, molecules and the use of electromagnetic radiation in understanding the tiny particles and the whole universe.					
List of Experiments :					
1) To determine the first excitation potential of a Gas by Frank-Hertz experiment.					
2) To find the wavelengths of the spectral lines of Hydrogen and hence determine the value of Rydberg constant.					
3) Determination of e/m of an electron.(Zeeman effect).					
4) Measurement of Magneto resistance of the supplied material.					
5) Observe diffraction of the beam of electrons on a graphitized carbon target and calculate the intra-atomic spacing's in the graphite.					
6) Determination of solar cell characteristics.					
7) Study of Dielectric constant and Curie temperature of a ferromagnetic sample.					
8) Determination of planks constant by planks blackbody radiation experiment.					
9) Determine the Band gap of a semiconductor by using four probe methods.					
10) Perform the Hall Effect experiment by recording the Hall voltage at different sample currents under different magnetic field strengths. Plot suitable graph and hence determine Hall coefficients. Identify conductivity type of the semiconductor.					
11) To study the dispersion relation for the monatomic and diatomic lattice.					
12) Familiarization with ORIGIN Graphing and Analysis Software for analysis of absorption & photoluminescence spectra and X-ray diffraction patterns (Demo).					
13) Preparation of e CdS nanostructures and record UV-Vis absorption spectra. Examine possible quantum confinement effect.					
Text Books :					
1) Advanced Practical Physics for students, B.L. Flint and H.T. Workshop, 1971, Asia PublishingHouse					
2) Advanced level Physics Practical's, Michael Nelson and Jon M. Ogborn, 4thEdition, reprinted 1985, Heinemann EducationalPublishers.					
3) A Textbook of Practical Physics, I. Prakash & Ramakrishna, 11thEd. 2011, Kitab Mahal.					

DSC	Electronics	L	T	P	C
		3	1	0	4
Pre-requisite: Preliminary concept of B.Sc. Physics course.					
Course Objectives: (1)To enhance the knowledge in band theory of solids and semiconductors. (2)To have a thorough knowledge on optical excitation and devices. (3)To have a broader concept on junctions to understand semiconductor devices. (4) To enhance the knowledge of transistors and their applications. (5) To develop the concept of oscillators.					
Course Outcome: After successful completion of the course, the students will be able CO 1: To remember different parameters related to the electronic devices. CO 2: To understand the basics of junction diodes, transistors, amplifiers, oscillators and CRO. CO 2: To apply the theories of basic electronic circuits to study their characteristics curves. CO 3: To analyze the results of different parameters related to the electronics circuits.					
Module 1: Junctions Diodes					12 hours
Fabrication and Types of Junctions, Unbiased PN junction, energy level diagram and built in potential, diffusion and drift of carriers: Einstein relation, biased PN junction, volt-amp characteristic of PN junction, effect of temperature on I-V characteristics, DC and AC resistance of PN junction, junction capacitance, zener diode, tunnel diode, light emitting diode, point contact diode, liquid crystal display.					
Module 2: Transistors					12 hours
Introduction, Bipolar Junction Transistor, Transistor currents, Transistor fabrication, Transistor Configuration and Characteristics, Common base and common emitter static characteristics, Transistor α and β , current and voltage notation, load line, transistor biasing:fixed bias or base bias, collector-feedback bias, emitter- feedback bias.					
Module 3: Amplifiers					20 hours
Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as a 2-port Network. H-parameter. Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage, and Power Gains. Classification of Class A, B & C Amplifiers. Differential amplifiers, Characteristics of an Ideal and Practical Op-Amp (IC 741). Open-loop and Closed-loop Gain.Frequency Response. CMRR. Slew Rate and Concept of Virtual Ground. Field effect transistors: JFET, MOSFET, FET amplified model and parameters, FET versus BJTs, Feedback principle.					
Module 4:Oscillators					8 hours
Types of oscillators, basic principle of oscillator, requirements of feedback oscillators, tuned-collector oscillator, Hartley Oscillator, Colpitts Oscillator, phase shift oscillator					
Module 5: Introduction to Cathode Ray Oscilloscope (CRO)					8 hours
Block Diagram of CRO. Electron Gun, Deflection System, and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.					
Total Lecture hours					60 hours
Text Book(s)					
1.	Streetman, B. and Banerjee, S., Solid State Electronics, Prentice Hall India, (2006).				
2	Jasprit Singh, Semiconductor Devices: Basic Principles by John Wiley &Sondptd Ltd Singapore				
3.	Donald Neamen , Dhruves Biswas “Semiconductor Physics and Devices” McGraw-Hill Education				
4.	C.T. Sah, Fundamentals of solid-state electronics, World Scientific Publishing Co Inc, 1991				
Reference Books					
1.	Y. Tsividis and M. Colin, Operation and Modeling of the MOS Transistor. Oxford Univ. Press, 2011				
2.	A.K. Maini, N. Maini, All-in-One Electronics Simplified, Khanna Book Publishing, New Delhi, 2021.				

SEC	Workshop Practice (Physics)	L	T	P	C
		0	0	8	4
Pre-requisite: Manufacturing Practice Workshop – I					
Course Objectives: The objectives of this course are:					
1. To impart knowledge and skill to use tools and equipment used.					
2. To educate students on the safe handling of machines and to develop hands-on practical skills.					
Course Outcome: After successful completion of this course, the students will be able to					
CO1: Identify and classify different parts of lathe, milling and shaper machine.					
CO2: Illustrate different tools and equipment used.					
CO3: Apply the techniques and knowledge for developing a particular job.					
Module 1: Lathe					
Introduction to lathe, Classification, Identification and function of different parts of lathe, Lathe accessories and attachments, List of tools & equipment used in lathe, Setting lathe in different speed and feed, Marking & sawing, Measurement using a caliper, bevel protector, and scale, Checking alignment of lathe centers. Adjustment of tool post. Mounting job between centers, Taper turning, other operations, Safety precautions. Facing operation to correct length, center drilling on lathe, step drilling, boring, step boring, threading, grooving, and knurling. Parallel turning, Step turning, chamfering.					
Module 2: Shaper					
Function, Classification, Different part of a shaper, Quick return and feed mechanism, Shaper Operations, Cutting speed and Machining time calculations, Safety precautions. Making jobs in shaper machine. Produce flat or plane surface, grooves using shaper. Cutting of external keyway on shaper.					
Module 3: Milling					
Introduction, Classification, Identification of tools used, Demonstrate working principle of milling machine, elements of a milling cutter, Milling processes – Up Milling , down milling, Set vice & job on the table of milling machine, Set arbor on the spindle of milling machine, Set the cutter on arbor, Set and align indexing head with reference to job on milling machine, Set the different machining parameters to prepare job, machining time, indexing and dividing head, indexing methods, spur and helical gear milling operations – Selection of cutter for gear cutting, Safety precautions.					
Sequence of milling six faces of a solid block, Checking accuracy, Perform Step milling using side and face cutter, Make concave surfaces and convex surface with accuracy, Make square job and hexagonal job by direct/ simple indexing method, Make spur gear using simple indexing,					
Text Book(s) :					
1.	Hajra Choudhury S.K., Hajra Choudhury A.K., and Nirjhar Roy S.K., “Elements of Workshop Technology”, Media promoters and publishers private limited, Mumbai, Vol. I 2008 and Vol. II 2010.				
2.	Kalpakjian S, Steven S. Schmid, “Manufacturing Engineering and Technology”, Pearson Education India Edition, 4th Edition, 2002				
3.	Rao P.N., “Manufacturing Technology”, Vol. I and Vol. II, Tata McGraw-Hill House, 2				
4.	A course in Workshop Technology, Vol-I & Vol-II, B. S. Raghuvanshi, Dhanpat Rai & Co., 2015				
Reference Books :					
1.	Workshop Practice–Singh S.,S.K. Kataria& Sons.2003.				
2.	A. Ghosh &A.K Mallik, Manufacturing Science, Publisher: OAFFO (1 January 2010), ISBN-10 : 8176710636				

DSC	General Laboratory-III	L	T	P	C
		0	0	8	4
Prerequisite : Graduate level Laboratory knowledge					
Course Objective					
(1) This course aims at performing basic physics experiments by the students. The students will be able to					
(2) The primary objective of this Physics lab is to provide students with practical experience in the field of physics.					
(3) Understanding the theoretical concepts learned in the classroom to real-life situations, enhancing their understanding of physical concepts.					
(4) This physics lab aims to develop critical thinking skills in students by giving them a brief idea about the work functioning of various electronics devices.					
(5) To design experiments and to learn to extract meaningful physics principles					
Course Outcome:					
CO1: To get practical experience in design, realization and verification of Biasing circuit for BJT & MOSFET.					
CO2: Simplify, design and implement Boolean expressions using basic/universal gates.					
CO3: Design and implement the various combinational circuits and sequential circuits.					
CO4: Understand basics of MATLAB syntax, functions and programming to generate and characterize of various types of signals.					
CO5: Selection and application of appropriate theorem for network simplification.					
CO6: Verify characteristics of Reflex Klystron.					
List of Experiments :					
(1) To plot the static collector characteristics of a Bipolar Junction transistor in the					
(2) Common Emitter and Common Base configuration.					
(3) To plot the static collector characteristics of a Bipolar Junction transistor in the Common Base configuration.					
(4) To plot the static drain characteristic of an-channel Power MOSFET in the Common source configuration.					
(5) To familiarize with logic gate IC packages and to verify the truth tables of logic gates.					
(6) To design and verify a half adder and half subtractor using Minimum no. of logic gates and NAND gate.					
(7) Design and set up a Multiplexer (MUX) using gates and ICs.					
(8) Implementation and verification of truth table for J-K flip-flop, Master-slave J-K flip-flop, D flip-flop and T flip-flop.					
(9) Design and implementation of Ring counter and Johnson counter using 4-bit shift register.					
(10) Define and sketch the following discrete time signals: a) unit step function $u(n)$ b) unit impulse signal $\delta(n)$ c) unit ramp signal $r(n)$ d) rectangular pulse signal of width 10 Use Subplot to plot the graphs in the same window					
(11) Sketch the following shifted unit step signals using subplot to plot on the same figure window. a) $u(n+2)$ b) $u(n-3)$ c) $u(n+2) - u(n-3)$					
(12) Generate the signal $x(n)= u(n) - u(n-10)$. Decompose $x(n)$ into odd and even components. Plot $x(n)$ and the odd and even components using subplot.					
(13) Determination transient response of a RC circuit and RL circuit.					
(14) To study frequency response of a Passive Low Pass Filter (LPF) and Passive High Pass Filter (HPF).					
(15) Verification of Thevenin's Theorem.					
(16) Verification of principle of Superposition Theorem with DC sources.					
(17) To study the Microwave Components.					
(18) To study the Power & Frequency of Reflex Klystron.					
(19) To study VSWR using Reflex Klystron.					
(20) To study Coupling Co-efficient and Directivity for a Directional Coupler using Reflex Klystron.					
Text Books :					
(1) The Art of Electronics Textbook by Paul Horowitz and Winfield Hill					

- (2) Digital Electronics - A Comprehensive Lab Manual Cherry Bhargava
- (3) MATLAB and Its Applications in Engineering, Book by Ashok K. Goel, Manoj Kumar Sharma, and Raj Kumar Bansal.
- (4) Basic Circuit Theory and Network Analysis Dr. D.C. Tayal

DSE	Material Synthesis & Characterisation	L	T	P	C
		3	1	0	4
Pre-requisite: BSc course on Nanoscience and nanotechnology					
Course Objective					
(1) Aims to enhance the concepts of nanostructures					
(2) To be familiar with different types of synthesis processes in detailed manner.					
(3) Enhance the knowledge of different conceptual theories for synthesis and chracterisation.					
(4) To have a broader perspective of the theories and relate them with experimental demonstration.					
Course Outcome:					
After successful completion of the course, the students will be able					
CO1: To understand various methods of synthesis, characterization and instruments related to them.					
CO 2: To apply the theoretical concepts in the process of synthesis and characterization.					
CO 3: To analyse various characteristics of the nanomaterials fabricated from various ways.					
CO 4: To evaluate the data processed from characterization.					
Module 1: Making nanostructures: top down					15 hours
Overview of nanofabrication: top down, Photolithography, Electron Beam Lithography, Micromechanical structure, Thin film technologies, Molecular Beam epitaxy, Self-assembled masks, Focussed ion beam milling, stamp technology, nanoscale junctions					
Module 2: Making nanostructures: bottom up					15 hours
Common aspects of all bottom-up assembly methods, organic synthesis, weak interactions between molecules, vesicles and micelles, thermodynamic aspects of self assembling nanostructures, a self assembled nanochemistry machine-the mitochondria, self assembled molecular monolayers, kinetic control of growth: nanowires and quantum dots, DNA nanotechnology					
Module 3: Microscopy and manipulation tools					15 hours
The scanning tunneling microscope, the atomic force microscope, electron microscopy, nano measurement techniques based on fluorescence, tweezers for grabbing molecules, chemical kinetics and single molecule experiments					
Module 4: Hands on Practices					15 hours
Demonstration of instruments available for various synthesis practices, demonstration of instruments available for various characterization techniques, concepts of data analysis					
Total Lecture hours					60 hours
Text Book(s)					
1.	Gouzhong Cao, Ying Wang: Nanostructures and Nanomaterials Synthesis, Properties and Applications, World Scientific, 2024				
2	Thomas Varghese, K. M Balakrishna, Nanotechnology An Introduction to Synthesis, Properties and Applications of Nanomaterials, Atlantic Publishers & Distributors Pvt Ltd, 2024				
3	Edward I. Wolf Nanophysics and Nanotechnology An Introduction to Modern Concepts in Nanoscience, Wiley India Pvt. Ltd				
4	S M Lindsay, Introduction To Nanoscience , Oxford University Press, 2009				
Reference Books					
1.	K.K Chattopadhyay, A N Banerjee, Introduction To Nanoscience and Nanotechnology, Prentice Halll India Learning Private Limited, 2009				
2.	Ashok Kumar, Introduction to Nanotechnology Synthesis, Chracterisation and Applications of Nanoparticles, Notion Press, 2022				

DSE	Advanced Electronics	L	T	P	C
		3	1	0	4
Pre-requisite: Graduation level Physics and Mathematics					
Course Objectives:					
To teach students the basics of digital circuits and Boolean algebra. To learn different concepts associated with arithmetic circuits and sequential circuits. To make students familiar with microprocessor architecture.					
Course Outcome:					
After successful completion of the course, the students will be able to CO1: Understand the working principle data processing circuits, arithmetic circuits and sequential circuits. CO2: Develop a digital logic and apply it to solve real life problems. CO3: Gain an understanding of microprocessor architecture.					
Module 1: DIGITAL CIRCUITS				13 hours	
Difference between analog and digital circuits, binary numbers, decimal to binary and binary to decimal conversion, BCD, octal and hexadecimal numbers. AND, OR and NOT gates, NAND and NOR gates as universal gates, XOR and XNOR gates.					
Module 2: BOOLEAN ALGEBRA				10 hours	
De Morgan's Theorems, Boolean laws, simplification of logic circuit using Boolean Algebra, fundamental products, idea of minterms and maxterms, conversion of a Truth table into equivalent logic circuit by (1) Sum of Products Method and (2) Karnaugh Map.					
Module 3: ARITHMETIC CIRCUITS				6 hours	
Binary addition, binary subtraction using 2's complement, Half and Full adders, Half and Full subtractors, 4-bit binary adder/subtractor.					
Module 4 : SEQUENTIAL CIRCUITS				9 hours	
SR, D and JK Flip-Flops, clocked (Level and Edge Triggered) Flip-Flops, Preset and Clear operations, race-around conditions in JK Flip-Flop, M/S JK Flip-Flop.					
Module 5: TIMERS				4 hours	
IC555: Block diagram and applications: Astable multivibrator and Monostable multivibrator.					
Module 6: SHIFT REGISTERS				6 hours	
Serial-in-Serial-out. Serial-in-Parallel-out. Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).					
Module 7: INTRODUCTION TO MICROPROCESSORS				12 hours	
8085 Microprocessor Architecture: Main features of 8085. Block diagram. Components, Pin-out diagram, Buses, Registers, ALU, Memory, Stack memory and Timing, Introduction to Assembly Language: 1-byte, 2-byte and 3-byte instructions.					
Total Lecture hours				60 hours	
Text Book(s)					
1.	Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw				
2.	Modern Digital Electronics, R.P. Jain, McGraw Hill Education, 4 th Edition.				
3.	Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.				
Reference Books					
1.	Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill.				
2.	Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.				

DSE	Thin Films Phenomena	L	T	P	C
		3	1	0	4
Pre-requisite: B.Sc. course on Nanoscience and nanotechnology					
Course Objective					
(1) Aims to enhance the concepts of thin films.					
(2) To be familiar with different types of synthesis processes in detailed manner.					
(3) Enhance the knowledge of different conceptual theories for synthesis and characterisation.					
(4) To have a broader perspective of the theories and relate them with applications.					
Course Outcome:					
After successful completion of the course, the students will be able					
CO1: To understand various methods of synthesis, characterization and instruments related to them.					
CO 2: To apply the theoretical concepts in the process of synthesis and characterization.					
CO 3: To analyze various characteristics of the thin film nanomaterials fabricated using various techniques.					
CO 4: To evaluate various parameters related to the characteristics of the thin film materials.					
Module 1: Introduction					15 hours
Basics of Thin films and Nanostructures, Role of thin films in Devices, Detailed Properties: Structural, electrical, magnetic, optical, thermal, thermoluminescence, differences between bulk and thin films					
Module 2: Fabrication					15 hours
Sol-gel synthesis, Spin coating, Chemical vapor deposition, Physical vapor deposition, Sputtering, ion implantation, Cathodic arc deposition, Pulsed laser deposition, Molecular beam epitaxy. Nucleation theories and growth models, Impact of parameters on film structure.					
Module 3: Characterisation					15 hours
x-ray diffraction, UV-vis spectroscopy, squid, four probe resistivity, atomic probe microscopy, profilometer, SEM, TEM					
Module 4: Applications					15 hours
Application of thin films in different areas such as electronics, microelectronics, energy storage and solar cells, medical, defence, sports, automobiles, etc.					
Total Lecture hours					60 hours
Text Book(s)					
1.	K. L. Chopra, Thin Film Phenomena Mc Graw Hill 1969.				
2	Thomas Varghese, K. M Balakrishna, Nanotechnology An Introduction to Synthesis, Properties and Applications of Nanomaterials, Atlantic Publishers & Distributors Pvt Ltd, 2024				
3	L. B Freund and S. Suresh, Thin Film Materials, Stress, Defect Formation and Surface Evolution Cambridge University Press, 2004.				
4	L.I. Maissel and R Glang, “Handbook of Thin Film Technology”, McGraw Hill, 1970				
Reference Books					
1.	G. Cao, “Nanostructures & Nanomaterials: Synthesis, Properties & Applications” Imperial College Press, 2004.				
2.	Alfred Wagendristel, Yuming Wang, An Introduction to Physics and Technology of Thin Films, World Scientific Press, 2006				

DSE	Network Analysis and Microwave Electronics	L	T	P	C
		3	1	0	4
Pre-requisite: Electricity and Electronics of B.Sc. Physics.					
Course objective:					
(1) Aims to understand the concepts of network analysis of electrical and electronic circuits and microwave devices (2) To be familiar with the electrical and electronic network and microwave devices and their applications to solve the problems (3) Enhance the knowledge of above mentioned circuits and devices (4) To acquire a broader perspective on electrical/electronic and microwave circuits and devices (5) To enhance knowledge on Network Analysis and Microwave devices such that the knowledge can be used critically.					
Course Outcome: After successful completion of the course, the students will be able to:					
CO1: Understand the concepts of electrical, electronic, microwave circuits and components. CO2: Familiarity with the theoretical components of knowledge on these devices/circuits. CO3: Analyze different electrical/ electrical /microwave circuits CO4: Apply this knowledge to solve the problems on these circuits CO5: Apply this knowledge to generate new circuits.					
Module 1	Network Analysis Methods	8 Hours			
Passive and active circuit elements, Voltage-Current relations, Kirchhoff’s Current Law (KCL) and Kirchhoff’s Voltage Law (KVL), Node voltage. Branch current method, Node voltage, and mesh current analysis methods with linearly dependent and independent sources of DC and AC networks.					
Module 2	Network Theorems	10 Hours			
Superposition theorem, Thevenin’s theorem, Norton’s theorem, Reciprocity theorem, Maximum power transfer theorem, and applications of these theorems. Two Port Networks: Two-port parameters, short circuit admittance parameters, open circuit impedance parameters, Transmission parameters, Image parameters, and hybrid parameters.					
Module 3	Network Analysis using Laplace Transformation	10 Hours			
Network Analysis Laplace Transformation: Laplace transformation, definition and properties, Inverse Laplace transformation, Partial Fraction Expansion, Heaviside’s expansion theorem. Source free RL and RC circuit, Step response of series RL, RC, RLC, parallel RLC, Response of series RL, RC, RLC, and parallel RLC to exponential driving sources.					
Module 4	Basic Idea of Microwave	12 Hours			
Microwave frequency, Difficulties of conventional devices at microwave frequencies, Microwave devices and systems, ground wave, sky wave, line of sight propagation, applications of microwave. Microwave transmission lines, primary parameters RLGC, Transmission line, parameters, transmission line equation and its solution, characteristic impedance, propagation constant, VSWR and reflection coefficient, Smith Chart, and Stub matching.					
Module 5	Microwave waveguides	10 Hours			
Rectangular waveguides, design and characteristics, TE and TM modes, solutions, velocity of propagation and losses, Dominant mode, Circular waveguides and solutions for TE and TM modes, Q-factors. Waveguide circuits, S-parameters, Tees, rings, circulators, isolators, and direction couplers.					

Module 6	Klystrons and Magnetrons	10 Hours
Klystrons: velocity modulation and bunching, Output powers. Reflex klystron, Multi-cavity klystron (qualitative). Travelling Wave Tube: Slow wave structures, Amplification process, Axial electric field, wave modes, gain consideration, Coupled cavity Travelling wave tube. Magnetron: Cylindrical magnetron, linear magnetron, Coaxial Magnetron, Voltage tunable magnetron, Inverted coaxial magnetron, forward and backward cross field magnetron.		
Text Book(s)		
1.	Network Analysis: M. E. Van Valkenburg	
2.	Fundamentals of Electric Circuits: Charles K Alexander and Matthew N O Sadiku, Mc Graw Hill	
3.	Network Analysis: G. K. Mithal	
4.	Principles of Electronics: V. K. Mehta	
	Electronic Devices and Circuit Theory: NashelskyBoylestad	
Reference Books		
1.	Microwave Devices and Circuits: S. Y. Liao, Pearson Education /PHI	
2.	Microwaves, K C Gupta, New Age Publishers	
3.	Microwaves: Introduction to Circuit Devices and Antennas: M. L. Sisodia and Vijay Laxmi Gupta	
4.	Microwave Electronics: A. D. Grigoriev, V. A. Ivanov	
	Microwave Electronic devices: T. G. Roer	

DSC	ELECTROMAGNETIC THEORY AND ELECTRODYNAMICS	L	T	P	C
		3	1	0	4
Pre-requisite: Preliminary concept of B.Sc. Physics course.					
Course Objectives:					
(1) To enhance the knowledge of electromagnetic theory.					
(2) To have a thorough knowledge about wave propagation in different media.					
(3) To have a broader concept of all wave theories by analysis.					
(4) To develop the understanding of various parameters and its relation to electrodynamics.					
Course Outcome:					
After successful completion of the course, the students will be able					
CO 1: To remember the laws and the parameters related to electromagnetic theory and electrodynamics.					
CO 2: To understand the mathematical theories of electromagnetic theory.					
CO 3: To apply Maxwell’s equations to understand the wave propagation in different media.					
CO 4: To analyze various results to understand the physical significance.					
Module 1: Maxwell’s equations					10 hours
Review of Maxwell’s equations, Physical significance of Maxwell’s equations, Displacement Current, Boundary conditions at interface between dielectric media, Wave equation, Poynting Theorem and Poynting Vector, Electromagnetic Energy (EM) Density.					
Module 2: EM wave Propagation					15 hours
Plane EM wave in (a) free space, (b) isotropic dielectric, (c) anisotropic dielectric, (d) conducting medium, (e) ionized gases, transverse nature of the plane EM waves, flow of energy, skin depth, refractive index and dielectric constant, electrical conductivity in ionized gases, plasma frequency, application of propagation in ionosphere.					
Module 3: Application of EM waves					15 hours
Reflection and Refraction of plane waves at plane interface between two dielectric media, Laws of Reflection and Refraction, Fresnel’s Formulae for perpendicular & parallel polarization cases, Brewster’s law, Reflection and Transmission coefficients, Total Internal Reflection, Dispersion in gases.					

Module 4:Polarisation of EM waves		12 hours
Description of Linear, Circular and Elliptical Polarisation, Uniaxial and Biaxial Crystals, Light Propagation in Uniaxial Crystals, Double Refraction, Polarisation by Double Refraction, Nicol prism, ordinary and Extraordinary refractive indices, Production and detection of polarized light, Phase retardation plates, Quarter wave and Half wave plate, Babinet Compensator, Optical Rotation, Biot’s laws for Rotatory polarization, Laurent’s half shade Polarimeter.		
Module 5: Electrodynamics		8 hours
Wave Guides, Electromagnetic Vector and Scalar Potentials, Lorentz Gauge, Coulomb or Transverse Gauge, Hertz Vector, Hertzian Oscillator, Radiation due to an oscillating electric dipole, retarded potential, Lienard-Wiechart potentials, Scattering and dispersion of em radiation, scattering by a free electron, by bound electron, dispersion, anomalous dispersion.		
Total Lecture hours		60 hours
Text Book(s)		
1.	David J Griffiths, Introduction to Electrodynamics, Cambridge University Press, (2025).	
2 .	Matthew N.O Sadiku, S.V Kulkarni, Principles of Electromagnetics, Oxford University Press, (2015)	
3.	Satya Prakash, Electromagnetic Theory and Electrodynamics, KNRN (2020)	
4.	John R. Reitz, Frederick J. Milford, Robert W. Foundations of Electromagnetic Theory, Narosa(1998)	
Reference Books		
1.	S. Salivahanan, S. Karthie, Electromagnetic Fields and Waves. Pearson, (2024).	
2.	James Clerk Maxwell, A Dynamical Theory of the Electromagnetic Field, Martino Fine Books(2013).	

DSC	Nuclear and Particle Physics	L	T	P	C
		3	1	0	4
Pre-requisite: Graduation level Physics and Mathematics					
Course Objectives:					
1. To have a basic knowledge of the nuclear force and its properties 2. To be able to visualize the nature of interaction of nucleons inside deuteron nucleus. 3. To acquire knowledge about different models regarding nucleus and nuclear reactions and decay processes 4. To develop a thorough understanding of the elementary particle interactions and principles of working of nuclear detectors.					
Course Outcome:					
After successful completion of the course, the students will be able to CO1: Understand the basics of nuclear forces and their properties. CO2: Understand the nature of interaction of nucleons inside deuteron nucleus. CO3: Apply the shell and collective models to predict nuclear properties like spin, parity, and magnetic moments. CO4: Compare and contrast the working principles of different radiation detectors and select an appropriate detector for a given experimental scenario.					
Module 1: BASIC NUCLEAR PROPERTIES					8 hours
Nuclear size determination from electron scattering, nuclear form factors, Angular momentum, spin, parity and symmetry and moments of nuclei (Electric and Magnetic).					
Module 2: TWO BODY PROBLEM					12 hours
General form of nucleon-nucleon forces, the deuteron problem (ground states and excited states), central and tensor forces, nucleon-nucleon scattering at low energies, magnetic and quadrupole moments of deuteron.					
Module 3: NUCLEAR MODELS					8 hours

Concept of Liquid drop model, Magic nuclei, nucleon separation energy, Single particle shell model (including Mean field approach, spin orbit coupling), limitations of the shell model, Physical concepts of the unified model (Collective Model).	
Module 4 : NUCLEAR REACTIONS	13 hours
Reaction channels, nuclear reaction mechanisms, scattering cross-section, compound nucleus, partial wave analysis of nuclear reaction, resonance, Breit-Wigner single level formula, B-W formula incorporating spin, nuclear fission, neutrino hypothesis and general features of β -ray spectrum, Fermi's theory of β -decay, Curie plot, selection rules.	
Module 5: ELEMENTARY PARTICLES	12 hours
Fundamental forces, Elementary particles and their classification, characteristics of the elementary particles, quantum numbers, behaviour under charge conjugation, time reversal and parity operation, Gellmann-Nishijima scheme, Properties of quarks and their classification. Elementary ideas of SU(2) and SU(3) symmetry groups and hadron classification. Introduction to the standard model. Electroweak interaction-W & Z Bosons.	
Module 6: DETECTORS OF RADIATIONS	7 hours
Interaction of radiation with matter (charged particles and photons), Basics of Solid state detectors, Scintillation and gas detectors for particle and electromagnetic radiation detection, Photomultiplier Tubes, HPGe detectors,	
Total Lecture hours	60 hours
Text Book(s)	
(1) Martin, B., Nuclear and Particle Physics: An Introductory, (Wiley, 2006). (2) Tayal, D. C., Nuclear Physics, (Pragati Prakashan, 2008). (3) Bernard L. Cohen, Concept of Nuclear Physics, (Tata McGraw-Hill Education Private Ltd, 2011). (4) Krane K. S., Introductory Nuclear Physics (John Wiley & Sons, 1987)	
Reference Books	
(1) Beiser, A. and Mahajan, S., Concept of Modern Physics, (Tata McGraw-Hill Pvt Ltd, 2009). (2) Griffiths, D., Introductory to Elementary Particles, 2nd edition, (Academic Press, 2008). (3) Perkins D. H., Introduction to High Energy Physics. (John Wiley & Sons Inc, 1987).	

DSE	Lasers and Spectroscopy	L	T	P	C
		3	1	0	4
Pre-requisite: Undergraduate courses in Quantum Mechanics, Atomic & Molecular Physics and Mathematical Physics					
Course Objectives:					
(1) To learn the basics of group theory and molecular symmetry. (2) To learn about electronic NMR and ESR spectra in detail. (3) To understand the basics of fluorescence spectroscopy to derive molecular information. (4) To study the fundamental of laser action and their applications.					
Course Outcome:					
After successful completion of the course, the students will be able to CO1: Understand the fundamentals of group theory and molecular symmetry. CO2: Interpret key features in molecular electronic spectra and explain the parameters governing fluorescence emission CO3: Analyse complex spectra of diatomic molecules CO4: Describe the operating principles of common lasers and their applications in spectroscopic analysis of materials					
Module 1: MOLECULAR SYMMETY AND GROUP THEORY					12 hours

Symmetry operations and point groups for molecules, the representation of a point group, matrices and basis sets, reducible and irreducible representations, application to vibrational spectroscopy.	
Module 2: MOLECULAR SPECTRA	20 hours
Electronic spectra of diatomic molecules – Fine structure of electronic transitions - rotational analysis, combination relations with and without Q branches, determination of rotational constants, internuclear distance and moment of inertia, determination of band origins Wave mechanical formulation of Franck Condon principle - overlap integral, band intensities in emission and absorption, vibrational sum rule and vibrational temperature. Intensity distribution in rotational structure - rotational temperature, intensity distribution in homonuclear molecules. Magnetic Resonance Spectroscopy (NMR & ESR) - Magnetic properties of nuclei, nuclear resonance, Spin-spin & amp, spin-lattice interaction, chemical shift, nuclear coupling.	
Module 3: FLUORESCENCE SPECTRA	10 hours
Luminescence: fluorescence and phosphorescence, Jablonski diagram, Characteristics of fluorescence emission, Fluorescence lifetimes and Quantum Yields, Fluorescence anisotropy, Resonance energy transfer, Steady state and Time-resolved fluorescence, Molecular information from fluorescence.	
Module 4: LASER FUNDAMENTALS AND APPLICATIONS	18 hours
Resonators – Modes of a resonant cavity: longitudinal & transverse laser modes; stability condition; Properties of Gaussian beams; single and multimode oscillations; Q switching; mode locking. Types of lasers – Nd: YAG laser, Dye laser, He : Cd laser, Excimer laser. Selected applications of lasers – Laser-induced fluorescence of vegetation and other biological materials.	
Total Lecture hours	60 hours
Text Books	
1.	Molecular Symmetry, D. J. Willock (John Wiley & Sons, 2009)
2.	Molecular Spectra and Molecular Structure, G. Herzberg (Van Nostrand, 1950)
3.	Group Theory and Physics, S. Sternberg (Cambridge Univ. Press, 1995)
4.	Modern Spectroscopy, J. M. Hollas (4th Ed., John Wiley, 2004)
5.	Molecular Quantum Mechanics, P Atkins & R. Friedman (Oxford Univ. Press, 2005)
6.	Laser Spectroscopy for Sensing Fundamentals, Techniques and Applications, edited by Matthieu Baudalet (Elsevier, 2014)
Reference Books	
1.	Essentials of Laser and Nonlinear Optics, G D Barua (Pragati Prakashan, 2019)
2.	Principles of Fluorescence Spectroscopy, J R Lakowicz (Springer, 2006)
3.	Lasers, A. E. Siegman, (Mill Valley, CA : University Science Books)
4.	Principles of Lasers, O. Svelto, (5 th Ed. Springer, 2010)

DSE	Nonlinear Optics	L	T	P	C
		3	1	0	4
Pre-requisite: B. Sc. Physics					
Course Objectives:					
(1) To understand non-linear optical susceptibility					
(2) To understand the wave equation and intensity, refractive index					
Course Outcome:					
After successful completion of the course, the students will be able to					
CO1: Acquire the knowledge about the nonlinear optical susceptibility and Kramers-Kronig relations in linear and nonlinear optics					
CO2: Understand the wave equation for nonlinear optical media and second harmonic generation					
CO3: Know the intensity dependent refractive index, semiconductor nonlinearity and semi empirical models of the nonlinear optical susceptibility					
CO4: Know the basic principle of electro optic and photo refractive effect					
CO5: Analyse the optical processes and ultrafast nonlinear optical processes					
Module 1: NONLINEAR OPTICAL SUSCEPTIBILITY					12 hours
Introduction of Nonlinear Optics, Description of Nonlinear Optical Processes, Definition of Nonlinear Susceptibility. Nonlinear susceptibility of a classical anharmonic oscillator. Properties of nonlinear susceptibility. Time domain description of optical nonlinearities. Kramers-Kronig relations in linear and nonlinear optics. Schrodinger calculation of nonlinear optical susceptibility..					
Module 2: WAVE EQUATION FOR NONLINEAR OPTICAL MEDIA					12 hours
The coupled wave equation for sum-frequency generation (SFG). Phase matching, quasi phase matching, the Manley Rowe relations, SFG, second harmonic generation, difference frequency generation and parametric amplification. Optical parametric oscillators. Nonlinear optical interactions with focused Gaussian beams. Semi empirical models of nonlinear optical susceptibility.					
Module 3: INTENSITY DEPENDENT REFRACTIVE INDEX					12 hours
Descriptions of the intensity, dependent refractive index. Tensor nature of the third-order susceptibility. Non resonant electronic nonlinearities, Nonlinearities due to molecular orientation, thermal nonlinear optical effects, semiconductor nonlinearities. Nonlinear susceptibilities: using time-independent perturbation theory and semi empirical models of non linear susceptibility.					
Module 4: SCATTERING, ELECTRO-OPTIC AND PHOTO-REFRACTIVE EFFECTS					12 hours
Spontaneous Raman Effect, spontaneous versus stimulated Raman scattering, stimulated Raman scattering described by nonlinear polarization, Stokes-AntiStokes coupling in stimulated Raman scattering. Rayleigh-Wing scattering. Introduction of the Electro-optic effect, linear electro-optic effect. Electro-optic modulators. Introduction of photo-refractive effect, two-beam coupling in photo-refractive materials.					
Module5: SCATTERING, ELECTRO-OPTIC AND PHOTO-REFRACTIVE EFFECTS					12 hours
Introduction to optical damage: Avalanche-breakdown model, Influence of laser pulse duration. Direct photo-ionization, multiphoton absorption and ionization. Ultrashort pulse propagation equation, interpretation of the ultra short pulse propagation equation, intense-field nonlinear optics. Motion of a free electron in a laser field. High harmonic generation, nonlinear optics of plasmas and relativistic nonlinear optics.					
Total Lecture hours					60 hours
Text Books					
1.	Lasers and Nonlinear Optics: B. B. Laud				
2.	Nonlinear Optics: Robert W. Boyd				
3.	Fiber-Optics Communication Systems: Govind P. Agarwal				
4.	Essentials of Nonlinear Optics: Y. V. S. Murti and C. Vijayan				
5.	Nonlinear Optics, Principles and Applications: Chunfei Lee				
Reference Books					

1.	Essentials of Laser and Nonlinear Optics, G D Barua (Pragati Prakashan, 2019)
2.	Principles of Fluorescence Spectroscopy, J R Lakowicz (Springer, 2006)
3.	Lasers, A. E. Siegman, (Mill Valley, CA : University Science Books)

DSC	General Laboratory- IV	L	T	P	C
		0	0	4	2
Prerequisite : Graduate level Laboratory knowledge					
Course Objective					
(1) This course aims at performing basic physics experiments by the students. The students will be able to					
(2) Understand and apply a broad range of measurement methods and techniques that are widely used in physics experiments;					
(3) Design experiments and make appropriate choices of measurement techniques and equipment;					
(4) This physics lab aims to develop critical thinking skills in students by giving them a brief idea about the work functioning of various spectroscopic devices.					
(5) To design experiments and to learn to extract meaningful physics principles					
Course Outcome:					
CO1: The students will be able to provide exposure in practical application of spectroscopic instruments.					
CO2: Demonstrate experiments using He-Ne lasers, Jamin’s interferometers, and Michelson interferometers for wavelength and grating measurements.					
CO3: Perform precise measurements and use spectroscopic equipment skillfully.					
CO4: Verify quantized energy levels and determine ionization potentials using experiments like Frank-Hertz and Zeeman effect.					
CO5: Understand the knowledge of spectrometers and determine unknown wavelengths with high accuracy.					
List of Experiments :					
(1) To draw the calibration curve of the Jamin's interferometer and then to find the refractive index of air at room temperature and pressure'					
(2) To determine the wavelength of light from a monochromatic source using Michelson's interferometer and then to determine the difference of wavelength for sodium D lines.					
(3) To determine the wavelength of He-Ne laser light.					
(4) To determine the wavelength of a laser light source using single slit and double slit					
(5) To Draw the BH Curve of Ferromagnetic Material Using Solenoid					
(6) To study the response of series and parallel LCR circuits and determine the Q - factor					
(7) Velocity of an ultrasonic wave in a given liquid by using Spectrometer.					
(8) To study the elliptically polarized light by using Babinet’s Compensator.					
(9) Determination of refractive index and Cauchy’s Constants of a prism using spectrometer by using Na Light source.					
(10) Find the Susceptibility of given paramagnetic substances (FeCl3) by Quinck’s tube Method.					
(11) Determination of e/m of an electron. (Zeeman Effect).					
(12) To determine the Specific rotation of Sugar solution using Polarimeter.					
Text Books :					
1.	ADVANCED PRACTICAL PHYSICS FOR STUDENTS, B.L. FLINT AND H.T. WORKSHOP, 1971, ASIA PUBLISHING HOUSE				
2.	ADVANCED LEVEL PHYSICS PRACTICAL’S, MICHAEL NELSON AND JON M. OGBORN, 4TH EDITION, REPRINTED 1985, HEINEMANN EDUCATIONAL PUBLISHERS.				
3.	TEXTBOOK OF PRACTICAL PHYSICS, I. PRAKASH & RAMAKRISHNA, 11TH ED. 2011, KITAB MAHAL.				

DSC	Research Methodology	L	T	P	C
		3	1	0	4
Pre-requisite: Preliminary concept of 12 th standard Physics					
Course Objectives: (1) To enhance the knowledge about the basic rules and types of research design. (2) To gain insights into how scientific research is conducted (3) To identify the influencing factor or determinants of research parameters. (4) To test the significance, validity and reliability of the research results					
Course Outcome: After successful completion of the course, the students will be able CO1: Acquire advanced knowledge of research paradigms and methodologies. CO2: Develop competence in computational and experimental tools. CO3: Learn advanced data analysis, modeling, and visualization. CO4: Understand research ethics, publication standards, and IPR. CO5: Prepare high-quality research proposals and preprints.					
Module 1: Introduction					10 hours
Research paradigms; theoretical, experimental, computational Physics research; identifying research gaps; formulating high-impact problems.					
Module 2: Scientific Tools					12 hours
Python, MATLAB, Mathematica; simulation tools (COMSOL, ANSYS, Quantum Espresso); high-precision instrumentation; scientific visualization					
Module 3: Data Analysis					14 hours
Statistical analysis; Monte Carlo simulations; numerical methods.					
Module 4: Ethics In Research					10 hours
Plagiarism tools; journal selection; peer review; patents; copyright; licensing; open-access policies; preprints.					
Module 5: Report Writing					14 hours
Writing research proposals; structuring chapters; preparing preprints; scientific communication presentation and defense skills.					
Total Lecture hours					60 hours
Text Book(s)					
1.	Research Methodology: A Step-by-Step Guide for Beginners — Ranjit Kumar				
2.	Research Design: Qualitative, Quantitative, and Mixed Methods Approaches —Creswell & Creswell				
Reference Books					
1.	The Craft of Research — Booth, Colomb & Williams				
2.	Qualitative Inquiry and Research Design — J.W. Creswell				

DSC	Advanced Research Laboratory	L	T	P	C
		0	0	8	4
Prerequisite : Graduate level Laboratory knowledge					
Course Objective					
(1) This course aims at performing basic physics experiments by the students. The students will be able to : (2) Understand and apply a broad range of measurement methods and techniques that are widely used in physics experiments; (3) Design experiments and make appropriate choices of measurement techniques and equipment; (4) Apply high-level computational and statistical techniques to datasets, including complex uncertainty analysis and model testing;					
Course Outcome:					
CO1: The students will be able to provide exposure in practical application of spectroscopic instruments. CO2: The students will be able to ascertain the atomic and molecular structures. CO3: Apply Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac statistics and understand basic models for phase transitions. CO4: Students will be able to understand atomic energy level splitting in a magnetic field, calculate the specific charge (e/m) of an electron, and verify quantum mechanical space quantization					
List of Experiments :					
(1) Velocity of an ultrasonic wave in a given liquid by using Spectrometer. (2) To study the elliptically polarized light by using Babinet’s Compensator. (3) Determination of refractive index and Cauchy’s Constants of prism using spectrometer (4) Find the Susceptibility of given paramagnetic substances (FeCl3) by Quinck’s tube Method. (5) Plot Planck’s law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature (6) Plot Specific Heat of Solids a) Dulong-Petit law b) Einstein distribution function c) Debye distribution functions for high temperature and low temperature and compare them for these two cases by using Scilab. (7) Plot the following functions with energy at different temperatures a) Maxwell-Boltzmann distribution b) Fermi-Dirac distribution c) Bose-Einstein distribution Course Code Course Title by using Scilab. (8) Familiarization with ORIGIN Graphing and Analysis Software for analysis of absorption & photoluminescence spectra and X-ray diffraction patterns (Demo). (9) Determination of e/m of an electron. (Zeeman Effect). (10) To determine the Specific rotation of Sugar solution using Polarimeter.					
Text Books :					
1.	ADVANCED PRACTICAL PHYSICS FOR STUDENTS, B.L. FLINT AND H.T. WORKSHOP, 1971, ASIA PUBLISHING HOUSE				
2.	ADVANCED LEVEL PHYSICS PRACTICAL’S, MICHAEL NELSON AND JON M. OGBORN, 4TH EDITION, REPRINTED 1985, HEINEMANN EDUCATIONAL PUBLISHERS.				
3.	TEXTBOOK OF PRACTICAL PHYSICS, I. PRAKASH & RAMAKRISHNA, 11TH ED. 2011, KITAB MAHAL.				

DSC	PG General Laboratory	L	T	P	C
		0	0	8	4
Prerequisite : Graduate level Laboratory knowledge					
Course Objective					
This course aims at performing basic physics experiments by the students. The students will be able to : (1) The students will able to understand the fundamental concepts of condensed matter physics and materials science such as lattice vibrations, thermal properties, free electron and band theory of solids. (2) Students will understand the different theories for solving electron problems in metals. (3) This lab will help the students to understand and Introducing basic concepts via diffraction methods, lattice vibrations and free electrons, Hall Effect. (4) Enhance the knowledge of students to the band structures for studying different materials					
Course Outcome:					
CO1: Measure temperature-dependent conductivity and band gap of semiconductors, and magnetic properties of materials. CO2: Operate test equipment such as oscilloscopes, logic probes, function generators and power supplies to study the operation of digital electronic circuits. CO3: Students will be able to answer about various spectroscopic techniques and their modern developments. CO4: Acquire knowledge of semiconductor materials and their characterization techniques. CO5: Analyze the structure, band diagram, and working of multi-junction and display devices.					
List of Experiments :					
(1) To find the wavelengths of the spectral lines of Hydrogen and hence determine the value of Rydberg constant. (2) Determination of solar cell characteristics. (3) Determination of planks constant. (4) Determine the Band gap of a semiconductor by using four probe methods. (5) Perform the Hall Effect experiment by recording the Hall voltage at different sample currents under different magnetic field strengths. Plot suitable graph and hence determine Hall coefficient. (6) To find the velocity of an Ultrasonic wave in a liquid by using spectrometer. (7) Measurement of susceptibility of paramagnetic solution (Quinck’s Tube Method). (8) To find the wavelength of a laser light source by using single slit and double slit method. (9) To Determine the Specific Rotation of Sugar using Laurent’s Half Shade Polarimeter (10) Construction of adder, subtractor, differentiator, and integrator circuits using the given OP-Amp. (11) Design the high pass and low pass filter. Calculate the lower cut off and higher cut-off Frequency and Calculate the gain (12) Verify De-Morgan’s law using Logic Gates circuit. (13) Design and realize Inverting and Non-inverting amplifier using OPAMP.					
Textbooks:					
1) ADVANCED PRACTICAL PHYSICS FOR STUDENTS, B.L. FLINT AND H.T. WORKSHOP, 1971, ASIA PUBLISHING HOUSE 2) ADVANCED LEVEL PHYSICS PRACTICAL’S, MICHAEL NELSON AND JON M. OGBORN, 4 TH EDITION, REPRINTED 1985, HEINEMANN EDUCATIONAL PUBLISHERS. 3) TEXTBOOK OF PRACTICAL PHYSICS, I. PRAKASH & RAMAKRISHNA, 11THED. 2011, KITAB					