M.Sc. Applied Physics

Semester - I

Course Code	**PT01CAPC51**	Title of the Course	**Basic Mathematical Tools**
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	This course paper consists of the basic mathematical theory. Physics is probably the one area of science where many areas of mathematics have been directly applied. This course enables students to impart knowledge about various mathematical methods employed to study physics problems.

Course Content		
Unit	Description	Weight age*
1.	Introduction, Analytic functions, Contour integrals, Cauchy-Riemann equations and their implications, Singularity, Pole, Laurent series, The Residue theorem, Methods of finding residues, Evaluation of definite integrals by use of the residue theorem, Mapping. Special functions: Hermite, Bessel, Laguerre and Legendre functions	25%
2.	Integral transforms, Fourier transform and its properties as well as applications such as Gaussian function, finite wave train, etc., Convolution theorem, momentum representation, Laplace transform and its properties, Laplace transforms of some elementary functions and derivatives including some applications in the problems of physics e.g. step function, simple harmonic oscillator, damped oscillator- RLC analogy etc.	25%
3.	Phase plane: Pendulum equation and its phase diagram, Autonomous equations in the phase plane, Phase diagram for the simple harmonic oscillator – weak and critical damping, Conservative systems, Damped linear oscillator, Nonlinear damping – dry friction, the brake, the pendulum clock, General phase plane for first-order system, Applications of Population Models – predator-prey problem, general epidemic, recurrent epidemic, Linear approximation at equilibrium points.	25%
4.	Tensors: Types of tensors and their algebra, Contraction and inner product, Metric tensors, Quotient rule, Dual and irreducible tensors, Christoffel symbols, covariant derivative, Geodesic equation.	25%

	Introduction to group theory: Definition and examples, group multiplication table, homomorphism and isomorphism, matrix representations – reducible and irreducible, classes and character, subgroups and cosets, Dihedral group, orthogonal groups and special unitary group, Illustrations of the group concept in various branches of physics.	

Teaching-Learning Methodology	• We make extensive use of chalk and board. • ICT tools such as multimedia projector, smart board, etc. are also used for better explanation of scientific concepts. • Detail lecture notes and other reference materials are also provided to the students as and when required from departmental library resources.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weight age
1.	Internal Written Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	On completion of the course student will be able to, 1. Learn about complex number and variable 2. Explain Fourier expansion, Integral transforms, Laplace transforms and Fourier transforms 3. Understand the phase diagram of different classical and mechanical systems and its applications 4. Explain tensor and its basic properties along with basic of Group theory

Suggested References:

Sr. No.	References

1. Mathematical Methods for Physicists by G. Arfken and Weber, Academic Press, 6th Ed (2005).
2. A text book of Quantum Mechanics, by Mathews &Venkatesan, TMH Publication (2010)
3. Mathematical Physics by P. K. Chattopadhyay (Wiley Eastern Limited, (1990).
4. Vector Analysis Murray Spiegel (Schuam Series).
5. Mathematical Methods in Physical Sciences by M. L. Boas, Second Edition, John Wiley & Sons, (1996).
6. Mathematical Methods of Physics by Mathews & Walker, 2nd Ed. 2004 Pearson Education, (Singapore) Indian Br. Delhi, India.
7. Elements of Group Theory for Physicists by A W Joshi, New Age Int. Pub, New Delhi (1997).
8. Nonlinear Ordinary Differential Equations by D. W. Jordan & P. Smith, Clarendon Press, Oxford (1976).
9. Matrices and Tensors in Physics by A W Joshi 3rd Ed., New Age International (P) Ltd. New Delhi

On-line resources to be used if available as reference material

On-line Resources

https://nptel.ac.in/courses/111/103/111103070/
https://nptel.ac.in/courses/111/102/111102129/
https://nptel.ac.in/content/storage2/courses/122106027/classicalphysics.pdf
https://nptel.ac.in/courses/112/103/112103167/
https://nptel.ac.in/courses/111/106/111106113/

M.Sc. Applied Physics

Semester – I

Course Code	**PT01CAPC52**	Title of the Course	**Physics of Atomic-Molecular Spectroscopy and Statistical Mechanics**
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	This course enables student to, 1. Provides a broad knowledge of characteristics of atoms and molecules. 2. Understand the theory related to rotational, vibrational, electronic and Raman spectra of molecules. 3. Explain basic Laser principles, Laser characteristics, its properties and applications. 4. Learn fundamental topics related to Quantum Statistical Mechanics and classification of phase transitions.

Course Content		
Unit	Description	Weight age*
1.	**Atoms and Molecules:** Schrödinger equation for one-electron atoms – H-atom, the dipole selection rules. Fine structure of hydrogenic atoms, The Lamb shift and its determination, Hyperfine structure and isotopic shifts. Schrödinger equation for Two-electron atoms, the role of Pauli Exclusion Principle, Energy levels of He atom, Doubly excited states, Auto-ionization in Helium. Thomas-Fermi model for many-electron atoms. The Born-Oppenheimer approximation for molecule, electronic structure of diatomic molecules, LCAO approximation for H_2^+ ion.	25%
2.	**Laser & Spectroscopy:** Emission and absorption spectroscopy: UV-visible-IR absorption (introduction),Classical view of Einstein coefficients; two-level system, Three-level Laser system, Variation of Laser power around threshold.NH_3 maser, He-Ne Laser (energy level diagram), CO_2 Laser, Semiconductor Lasers, Rayleigh and Raman scattering, Stimulated Raman effect, Hyper-Raman effect: Classical treatment, Quantum mechanical treatment, Coherent anti-stokes Raman scattering (CARS), Spin-flip Raman Laser, Free-electron Laser	25%
3.	**Classical Statistical Mechanics:** Canonical ensemble: Physical	25%

	significance of various statistical quantities, energy fluctuations, the equipartition and the virialtheorems, a system of harmonic oscillators Grand-canonical ensemble: Physical significance of various statistical quantities, density and energy fluctuations, classical ideal gas, a system of independent, localized particles **Quantum Statistical Mechanics:** Formulation: Quantum microstate and microstate, density matrix and its properties, density matrices and partition functions for microcanonical, canonical and grand-canonical ensembles. Ideal quantum gases: Hilbert space of identical particles, canonical formulation, degenerate Fermi gas, degenerate Bose gas	
4.	**Non-equilibrium Statistical Mechanics:** Classification of phase transitions, Landau theory of second order phase transition, Examples of phase transitions, Ising model in one and two dimensions, Critical indices, Scaling laws, Boltzmann Transport Equation, Boltzmann H – theorem, Theory of Brownian motion, Diffusion equation.	25%

Teaching-Learning Methodology	• We make extensive use of chalk and board. • ICT tools such as multimedia projector, smart board, etc. are also used for better explanation of scientific concepts. • Detail lecture notes and other reference materials are also provided to the students as and when required from departmental library resources

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weight age
1.	Internal Written Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	On completion of the course student will be able to, 1. Describe operational principles and construction of lasers. Also, relate the laser

	theories to atom and molecular physics, solid state physics, quantum mechanics. 2. Carry out theoretical studies on atoms and molecules physics viz. Lamb shift, Hyperfine structure, Born-Oppenheimer approximation, electronic structure of diatomic molecules 3. Gets acquainted with advanced topics such as Ising model, Boltzmann Transport Equation, Diffusion equation, Classification of phase transitions etc.

Suggested References:

Sr. No.	References:

1. Physics of Atoms and Molecules, by B. Bransden and C. J. Joachain (Pearson Education Publication, New Delhi).
2. Fundamentals of molecular spectroscopy, by C. N. Banvel.
3. LASERS Theory and Applications, by K. Thyagarajan and A. K. Ghatak (Macmillan India Ltd., 2008).
4. Lasers and Non-linear Optics, by B. B. Laud (New Age International P Ltd., India, 2nd edition, 1996).
5. Mechanics, 3rd Ed. by Landau &Lifshitz, Pergamon Press, 1976
6. Statistical Mechanics, by R K Pathria, 2nd Ed. 1996, Butterworth- Heinemann, Ordan Hill, Oxford.
7. Statistical Mechanics, by Kerson Huang, Jhon Wiley & Sons, 1987
8. Thermodynamics and Statistical Mechanics, by Griener, Neise and Stoecker, Springer-Ind., Ed.1997.
9. Statistical Mechanics, by R K Srivastava and J Ashok, Prentice Hall of India, 2005

On-line resources to be used if available as reference material

On-line Resources

https://nptel.ac.in/courses/115/101/115101003/
https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-cy13/
https://nptel.ac.in/courses/115/106/115106111/
https://nptel.ac.in/courses/115/103/115103113/

M.Sc. Applied Physics
Semester - I

Course Code	**PT01CAPC53**	Title of the Course	**Applied Electronics**
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	This course enables student to, 1. Learn the fundamental knowledge of PN junction-based devices. 2. Understand basic of Non-linear Integrated Circuits and operation of semiconductor devices. 3. Educate the use of BCD codes in digital circuits with the concepts for the design of comparators, Multiplexers, Registers, Counters, OPAMP etc.

Course Content		
Unit	Description	Weight age*
1.	**PN Junction Based Devices** Introduction to P-N Junction-Barrier Potential and I-V Characteristics, Applications of P-N junctions- Diode as clipper, Diode as a clamper circuit, Diode as a switch, Reverse Recovery time of diode, optoelectronic devices, light emitting diode, photodiode and phototransistor, solar cells, Uni-junction Transistor, Silicon control rectifier, DIAC and TRIAC, Applications of some solid-state devices.	25%
2.	**Non-linear Integrated Circuits** Block diagram of Operational Amplifier IC 741, Characteristics and parameters of Op-Amp, Op-Amp- comparator, Schmitt Trigger, UTP and LTP determination, Timer IC 555 block diagram and working, Timing waveform generators using IC 555- monostable and Astable multivibrator, more applications of IC 555 Timer – delay timers, sequential timer, pulsed-tone oscillator, voltage-controlled oscillator	25%
3.	**BCD Codes and Digital Circuits** Review of Binary Coded Decimal codes, Boolean functions, Min-terms and Max-terms. Karnaugh Mapping, Tri-state logic, positive and negative logic, signed binary numbers. Arithmetic logic circuits: Adders- Half adder and Full adder, Subtractors, comparators, Combinational and Sequential Circuits-	25%

	Decoders, De-multiplexers, Encoders, Multiplexers, Registers and Counters and its applications.	
4.	**Applications of Digital Circuits** Memories: Read Only Memory, Programmable Read Only Memory, Erasable Programmable Read Only Memory & Random-Access Memory, expanding memory size. Digital to Analog and Analog to Digital Convertors: Resistive divider, Binary ladder, Digital to Analog Convertor using OPAMP, specifications, parallel comparators, counter method & approximation methods.	25%

Teaching-Learning Methodology	• We make extensive use of chalk and board. • ICT tools such as multimedia projector, smart board, etc. are also used for better explanation of scientific concepts. • Detail lecture notes and other reference materials are also provided to the students as and when required from departmental library resources.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weight age
1.	Internal Written Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	On completion of the course student will be able to, 1. Gain a fundamental understanding of the following topics: optoelectronic devices, light emitting diode, photodiode and phototransistor, solar cells, Uni-junction Transistor, Silicon control rectifier, DIAC and TRIAC 2. Identify the various digital ICs and understand their operation. 3. Learn and understand the Basics of digital electronics and able to design basic logic circuits, combinational and sequential circuits.

Suggested References:

Sr. No.	References

1. Solid State Pulse Circuits by David A. Bell; Prentice Hall of India, New Delhi
2. Digital Electronics by Malvino & Leech.
3. Microelectronics: Digital and Analog by K. R. Botkar.
4. Integrated Electronics by K. R. Botkar.
5. Electronic Devices & Components by J. Seymour
6. Operational Amplifier by Ramakant Gaekwad

On-line resources to be used if available as reference material

On-line Resources

https://nptel.ac.in/courses/117/107/117107095/
https://nptel.ac.in/courses/108/108/108108122/
https://nptel.ac.in/courses/117/106/117106086/
https://nptel.ac.in/content/storage2/courses/112103174/pdf/mod3.pdf

M.Sc. Applied Physics

Semester - I

Course Code	**PT01CAPC54**	Title of the Course	**Experimental Methods-I**
Total Credits of the Course	4	Hours per Week	8

Course Objectives:	This course enables students to, 1. To gain practical knowledge by applying the experimental methods to correlate with the theory. 2. To learn the usage of different systems for various measurements. 3. Apply the electronics devices and graphical analysis to the experimental data.

Course Content
1. Frequency response of LDR using different filters 2. Determination of Resistivity of a semiconductor using Four Probe method 3. Arithmetic operations through combinational Logic Circuits 4. LCR Damped Harmonic Oscillator 5. Wave shaping circuits (using R, C and D) 6. Determination of e/k using a power transistor 7. Analog to Digital Convertor

Teaching-Learning Methodology	-----

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weight age
1.	Internal Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	• Practical's are conducted based on theory papers in order to strengthen the understanding behind concepts. • Students are exposed to sophisticated analytical instruments.

Suggested References:	
Sr. No.	References

On-line resources to be used if available as reference material
On-line Resources

M.Sc. Applied Physics

Semester - I

Course Code	**PT01CAPC55**	Title of the Course	**Experimental Methods-II**
Total Credits of the Course	4	Hours per Week	8

Course Objectives:	This course enables students to, 1. To gain practical knowledge by applying the experimental methods to correlate with the theory. 2. To learn the usage of different systems for various measurements. 3. Apply the electronics devices and graphical analysis to the experimental data.

Course Content
1. Thermistor characteristics and estimation of the band gap of the semiconducting material 2. Measurement of dielectric constant of solid materials by resonance method 3. Determination of the Planck's Constant using LED 4. Dead time determination of a Geiger-Muller Counter 5. Analysis of solar absorption spectra using Hart-Mann formula 6. Study of chaos through the logistic map of a population growth 7. Zeeman Effect

Teaching-Learning Methodology	-----

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	• Practical's are conducted based on theory papers in order to strengthen the understanding behind concepts. • Students are exposed to sophisticated analytical instruments.

Suggested References:	
Sr. No.	References

On-line resources to be used if available as reference material
On-line Resources

M.Sc. Applied Physics

Semester - I

Course Code	**PT01CAPC56**	Title of the Course	**Comprehensive Viva**
Total Credits of the Course	1	Hours per Week	2

Course Objectives:	Comprehensive viva is conducted to evaluate the overall knowledge gained by the student during the entire semester and related to the project work

Course Content	
Comprehensive viva contains all theory topics mentioned in paper code PT01CAPC01-3 & PT01EAPC1-2.	
Teaching-Learning Methodology	• Individual/group discussion • Interactive session • Problem solving • Written work

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weight age
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Comprehensive viva is conducted so as to evaluate the overall knowledge gained by the student during the entire semester.

Suggested References:	
Sr. No.	References

On-line resources to be used if available as reference material

On-line Resources:----------

M.Sc. Applied Physics

Semester - I

Course Code	**PT01EAPC51**	Title of the Course	**Nanoscience & Applied Materials**
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	This course enables student to, 1. Explain the fundamental principles of nanotechnology and their applications. 2. Learns the various approaches to synthesis nanomaterials 3. Expose them to the emerging area nanotechnology in industries and environment.

Course Content		
Unit	Description	Weight age*
1.	Nanoscience & Nanotechnology- Definition, Concepts: Top down and Bottom up, Fundamentals of Nano-science and Nanotechnology, Classification of Nanostructure, Dimensionality & Quantum Confinement, Nanostructured materials, size dependant properties of nanomaterials.	25%
2.	Chemical processes: Chemical precipitation and co-precipitation, polyol, and borohydrate reduction methods, Sol-Gel synthesis; Microemulsions synthesis, Hydrothermal, Solvothermal synthesis methods, Microwave assisted synthesis; Sonochemical assisted synthesis, Core-Shell nanostructure, Quantum dot (QDs) synthesis.	25%
3.	Carbon nanostructures: Clusters, nanotubes, fullerenes etc., fabrication of carbon nanotubes (Arc discharge method, laser ablation method, CVD method) Electrical, Vibrational and mechanical properties, applications of carbon nanotubes as field emission, EMI shielding, FETs, chemical sensors, catalysis and mechanical reinforcement.	25%
4.	Nanotechnology: Nanostructured ferromagnetism (basics, dynamics and ferromagnets and fluids), biological materials, nanostructures, nano wires and protein nanoparticles, biological nanostructures (proteins, micelles, vesicles, multilayered films), energetic and	25%

	chemical transformation of biological nanomaterials, nanomedicine, biomolecular sensing.	

Teaching-Learning Methodology	• We make extensive use of chalk and board. • ICT tools such as multimedia projector, smart board, etc. are also used for better explanation of scientific concepts. • Detail lecture notes and other reference materials are also provided to the students as and when required from departmental library resources.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weight age
1.	Internal Written Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	On completion of the course student will be able to, 1. Understands the classification and properties of nanostructured materials. 2. Learn topics related to size dependent properties of nanomaterials. 3. Educate various top-down and bottom-up approaches for nanomaterial synthesize and deposition of nanomaterials by various methods.

Suggested References:	
Sr. No.	References
	1. Charles P. Poole, Jr., Frank J. Owens; Introduction to Nanotechnology, Wiley-India 2. Nanotechnology: Principles and practices by Sulabha K. Kulkarani, Springer Publication 3. David S. Goodsell; Bio nanotechnology- lessons from nature, Wiley-India 4. Carbon Nanomaterials by Yuri Gogotsi, Volker Presser, CRC Press

On-line resources to be used if available as reference material
On-line Resources

https://nptel.ac.in/courses/113/106/113106093/
https://nptel.ac.in/courses/118/104/118104008/
https://nptel.ac.in/courses/118/102/118102003/
https://nptel.ac.in/courses/118/107/118107015/

M.Sc. Applied Physics

Semester - I

Course Code	**PT01EAPC52**	Title of the Course	**Numerical and Statistical Methods for Applied Physics**
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	This course enables student to, 1. Get a wide knowledge of numerical methods in computational physics that can be used to solve many problems which does not have an analytic solution. They will learn different method to solve differential equations. 2. Provides foundational knowledge of collection and classification of data, ordinary and partial differential equations, and algebra of matrices. 3. Give brief introduction of probability and importance of distribution of discrete and continuous random variables.

Course Content		
Unit	Description	Weight age*
1.	A Calculus refresher- functions and their derivatives – derivative as rate of change – Higher Order Derivatives - Maxima and Minima – Integration - Partial Derivatives – Taylor series - Gradient, Divergence and Curl - Hessian- Maxima and Minima. Vectors in R^n and matrices- algebra of matrices- inverse of a matrix- determinant and trace- eigen values and eigen vectors- projections and orthogonal matrices.	25%
2.	Ordinary differential equations- linear equations of first and second order –systems of linear differential equations- stability of solutions of linear systems of ODE- Legendre, Hermite and Bessel equations and polynomials. Partial differential equations of science and method of reparation of variables-Applications.	25%
3.	Numerical Analysis- Newton Method for implicit equation f (x) = 0 – Eular's method and Runge-Kutta method for ordinary differential equations – Methods of Elementary Error Analysis.	25%

	Collection and classification of data- frequency table- graphical representations of data- measures of central tendancy: mean, median, mode- measures of dispersion: variance standard deviation, coefficient of variation.	
4.	Random Variables- probability- joint, marginal and conditional probability – discrete and continuous random variables – probability distribution functions- Expectation and Moments – Binomial, Poisson and Normal distributions- a compendium of some other distribution functions. Testing of hypotheses – goodness of fit tests- chi-square test- tests of significance- one sample tests for mean- z test and t-test – two sample tests for means and variance.	25%

Teaching-Learning Methodology	• We make extensive use of chalk and board. • ICT tools such as multimedia projector, smart board, etc. are also used for better explanation of scientific concepts. • Detail lecture notes and other reference materials are also provided to the students as and when required from departmental library resources.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weight age
1.	Internal Written Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	On completion of the course student will be able to, 1. learn a broad foundational knowledge of collection and classification of data, ordinary and partial differential equations, algebra of matrices and distribution functions.

Suggested References:	
Sr. No.	References
	1. Introduction to Geochemical Modelling, Francis Albarede, Cambridge University Press (Relevant Materials from Chapters: 1-4) 1995. 2. Higher Engineering Mathematics (37th Edition), B. S. Gerwal, Khanna Publishers 3. Pisani and Purves – Statistics, Freedman, W.W. Norton & Co., 2011.

On-line resources to be used if available as reference material
On-line Resources
https://nptel.ac.in/courses/111/106/111106101/ https://nptel.ac.in/courses/111/107/111107062/ https://nptel.ac.in/courses/111/107/111107105/ https://nptel.ac.in/courses/122/102/122102009/