ST. ALOYSIUS COLLEGE(AUTONOMOUS), JABALPUR

Reaccredited 'A++ 'Grade by NAAC(CGPA:3.58/4.00)
College with Potential for Excellence by UGC
DST-FIST Supported & STAR College Scheme by DBT

Faculty of Science

Master of Science (M.Sc.)

SUBJECT: PHYSICS

M.Sc. I Semester

Under CBCS System

Paper-I

MATHEMATICAL PHYSICS (CC-11)

Course Outcomes

	Course Outcomes After completing the course students will be able to	**Cognitive Level**
CO-I	Understand the early life, education, and historical context of Aryabhata and Bhaskar Acharya(II) dwiteey	U, R
CO-II	Develop a strong foundation of mathematical tools such as Laplace & Fourier Transform, Special functions, Curvilinear coordinates, Probability, Group theory, Complex analysis and Tensor.	U, Ap,An, E
CO-III	Apply mathematical techniques to solve scientific & engineering problems and model real-world situations into mathematical formulations	Ap, An, E
CO-IV	Solve quantitative problems by applying mathematical models to predict or analyse physical behaviour.	U, Ap, An, C

R-Recall, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Content of the Course

Theory

Maximum Marks: 60

Units	Topics
I	**Curvilinear Coordinates, probability and Group theory** A brief biography of Aryabhata and Bhaskaracharya II with their major contribution to science and society. Introduction to Curvilinear Coordinates, Orthogonal curvilinear coordinates, differential of an arc length, differential operators, spherical and cylindrical coordinates and their unit vectors. Elementary probability theory, Conditional Probability, Bayes theorem, random variables, binomial, Poisson and normal distributions. Central limit theorem. **Group theory**: Introductory group theory, Special unitary group of degree two SU(2), Special orthogonal group of degree three SO(3). **Activity:** **1.** Ask students for a group discussion on contributions of Indian mathematicians. 2. Ask students to make charts on group theory [SU(2), SO(3)]. 3. Organize debate on historical time units (e.g. Yuga, kalpa) and ask them to convert in modern unit.
II	**Special Functions** **Legendre function:** Legendre's equation, Legendre's polynomial and its generating function, Recurrence formula, General solution of Legendre equation, Rodrigue's formula, Orthogonality of Legendre Polynomials. **Bessel functions**: Bessel equation and its solution, Bessel functions Jn(x),Recurrence formula and generating function, Orthogonality of Bessel function.

	Hermite's Function: Hermite's equation, Generating function of Hermite polynomials, Orthogonal property of Hermite polynomials, Recurrence formula for Hn(x) of Hermite equation.
III	**Complex Analysis** Introduction to Complex Numbers and their Graphical Representation, Functions of Complex Variables, Analyticity of complex function, Cauchy Riemann equation, **Singularities**: poles, removable singularity, essential singularity, branch points, Cauchy theorem, Cauchy integral formula, Laurent and Taylor's expansion. Residues and Residue Theorem. Application of Contour Integration in solving Definite Integrals
IV	**Fourier and Laplace transform:** Fourier Transform: Integrals Transforms, Fourier Integral theorem (Statement only), Fourier Transform, Fourier sine and cosine transform, Fourier transform of single pulse, trigonometric, exponential functions, Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem, Properties of Fourier transforms. Laplace transforms: Definition, Laplace transform of Elementary functions, Properties of Laplace transforms, Change of Scale Theorem, Shifting Theorem, Laplace transforms of derivatives, Derivatives and Integrals of Laplace transforms, Laplace transform of Unit Step function and Periodic Functions, Convolution Theorem, Inverse Laplace transforms, Solution of heat flow along semi-infinite bar using Laplace transform.
V	**Tensor Analysis** Tensors- Notations and Conversions, Contravariant tensors, Rank of the Tensors ,Properties of the Tensors e.g. Addition, Subtraction and Product, Contraction, Cartesian tensors and their transformation properties Eigen values of second rank tensors, Quotient law, Higher Rank Tensors with examples from piezoelectricity, stiffness and compliance.

References

Suggested Readings:

1. K. V. Sarma (1997), Aryabhata, National Book Trust, India.
2. Boas M. L., "Mathematical Methods in the Physical Sciences", Wiley, Third edition.
3. Arfken G.B., Weber H.J., Harris F.E., "Mathematical Methods for Physicists", Elsevier,7th edition.
4. Spiegel M.R., "Fourier Analysis", Tata McGraw-Hill, 2004.
5. Fokas A. S. & Ablowitz M.J., "Complex Variables", Cambridge Univ. Press,2011, 8th edition.
6. Dass H.K. &Verma R., "Mathematical Physics", S. Chand, Eighth Edition.
7. Mathematical Physics With Applications - V. Balakrishnan, Springer
8. Joshi A.W, Matrices and tensors in physics, Wiley, Third edition
9.Joshi A. W, Elements of Group Theory for Physicist, New Age International, Fourth Edition
10. Erwin kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, Tenth edition
11. Vasishtha A.K and Gupta R. K,Integral Transforms, Krishna Prakashan Mandir,2016
12. Sharma J.N Function of Complex Variable, Krishna Prakashan Mandir.

Suggested equivalent online courses:

https://www.youtube.com/watch?v=s-_3v3xEvHU

https://www.youtube.com/watch?v=WBF5hyrHStw

https://www.youtube.com/watch?v=peZWarEjk44

https://www.youtube.com/watch?v=B2VrnJsceW0

https://www.mit.edu/courses/8-962-general-relativity-spring-2020/video_galleries/video-lectures/

https://www.youtube.com/playlist?list=PLhSp9OSVmeyJ5N-JUEZj7uS6IAT9a79nD

https://www.youtube.com/playlist?list=PLhSp9OSVmeyIYLVvSJ8m6KvVwJs7M9QBm

https://www.youtube.com/playlist?list=PLp0hSY2uBeP-O0PDasx0dkQle779r8hqq

ST. ALOYSIUS COLLEGE(AUTONOMOUS), JABALPUR

Reaccredited 'A++ 'Grade by NAAC(CGPA:3.58/4.00)
College with Potential for Excellence by UGC
DST-FIST Supported & STAR College Scheme by DBT

Faculty of Science

Master of Science (M.Sc.)

SUBJECT: PHYSICS

M.Sc. I Semester

Under CBCS System

Paper-II

CLASSICAL MECHANICS (CC-12)

Course Outcomes

	Course Outcomes	Cognitive Level
CO-I	Understand the historical background and contributions of C.V. Raman and Meghnad Saha	U, R
CO-II	Formulate Lagrange's and Hamilton's equations of motion and understand their applications	U, Ap,An, E
CO-III	Apply the variational principle and principle of least action to solve physical problems.	U, Ap, An, E
CO-IV	Define and apply canonical transformations and generating functions	U, Ap, C
CO-V	Analyze small oscillations and determine normal modes of vibration	An
CO-VI	Understand the motion of rigid bodies	U

R-Recall, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Content of the Course

Theory

. **Maximum Marks:** 60

Units	Topics
I	**Lagrangian and Hamiltonian Dynamics** 1. Historical background and contributions of C.V. Raman (regarding study of elastic vibrations, wave mechanics), Meghnad Saha ionization equation (statistical mechanics, thermodynamics – classical roots). 2. Newtonian mechanics of a system of particles, Constraints and their classification, Generalized coordinates, Principle of virtual work, D'Alembert's Principle in generalized coordinates, Langrange's equation from D- Alembert principle, Generalized Potential, Lagrangian for a charged particle moving in EM field, Application: Single particle in Space, Simple pendulum, Atwood's machine, Bead sliding on rotating wire. 3. Generalized momentum and cyclic coordinates, Hamiltonian function and conservation of energy, Hamilon's equations, Hamilon's equations in different coordinate systems. **Activities:** 1. Ask students to study about Indian scientists and their work related to classical mechanics. 2. Poster on evolution from classical mechanics to quantum mechanics. 3. Organize debate on various contributions of Indian Scientist (Meghnad Saha, C.V. Raman, Satyendra Nath Bose, J.C. Bose))
II	**Central forces and Variational principles** **1.** Variational principle, Euler-Lagrange's equation from variational principle, Applications: shortest distance between two points and

	Brachistochrone problem, Deduction of Hamilton principle from D-Alembert principle, Lagrange's equations of motion for Non-Holonomic system and Lagrange's Multipliers, Principle of least action.
III	**Canonical transformation and Brackets** 1. Canonical Transformation, Legendre transformation, Generating functions, Application of canonical transformation. 2. Poisson's Brackets and their properties, Lagrange Brackets and their properties, Invariance of Poisson's Bracket with respect to canonical transformation, Jacobi's Identity, Phase space and Liouville's Theorem.
IV	**Hamilton- Jacobi formulation and Small oscillation** 1. Hamilton- Jacobi equation, Solution by Hamilton- Jacobi method: Harmonic oscillator, Kepler's Problem, Action and angle variables. 2. One-dimensional oscillator, Two coupled oscillators, Normal Coordinates and Normal Modes, Kinetic and potential energy in normal coordinates, General theory of small oscillation, Secular equation and Eigen value equation,
V	**Non-inertial systems** 1. Euler's angles, Infinitesimal rotations as vectors (Angular velocity), Angular Momentum and Inertia tensor. 2. Euler's equations of motion for a rigid body, Torque- free motion of a rigid body, Motion of a heavy Symmetrical top, Gyroscope. 3. Non-inertial Frame of reference, Fictitious Force, Uniformly rotating frames, Coriolis force, Free fall of a body on Earth's Surface.

Keywords/Tags: Generalized coordinates, Variational principle, Poisson's Brackets, Hamilton- Jacobi equation, Coriolis force.

References

Suggested Readings:

1. Goldstein H., Poole C.P., Safko J.L., "Classical Mechanics", Pearson Education,2002, 3rd Edition.

2. Landau L. D., Lifshitz E. M., "Mechanics", Pergamon,1976.

3. Upadhyaya J. C., "Classical Mechanics", Himalaya Publishing House.

4. Gupta S.L., Kumar V., Sharma, "Classical mechanics", Pragati Prakashan.

Suggested equivalent online courses:

https://ocw.mit.edu/courses/8-03sc-physics-iii-vibrations-and-waves-fall-2016/pages/part-i-mechanicalvibrations-and-waves/

https://ocw.mit.edu/courses/8-01sc-classical-mechanics-fall-2016/pages/week-2-newtons-laws/4-4-noninertial-reference-frames/

https://www.youtube.com/watch?v=NE73aD0ELtI&t=361s
https://www.youtube.com/watch?v=0DHNGtsmmH8
https://www.youtube.com/watch?app=desktop&v=pB-aleLeKL0&t=0s
https://www.youtube.com/watch?v=nFpC1s1joRU

https://www.youtube.com/watch?v=z-dGZgq-6jg

https://www.youtube.com/watch?v=qYnvc4rKeuA

https://www.youtube.com/watch?v=3iuBKOxAIWg

PRACTICAL

Lab-1 (PC-11)

1. Determine the value of Rydberg's constants with the diffraction grating and hydrogen tude.
2. 2. To determine the hysteresis loss of a given transformer by CRO.
3. To find the maximum power and efficiency of a solar cell.
4. Study the temperature dependence of resistivity of a semiconductor and to determine the band gap of the material.
5. To verify Fresnel's formula for the reflection of light
6. To compare Self-inductance of two coils L1 and L3 with Maxwell Bridge.
7. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ2–T law.
8. Determination of Lande's 'g' factor of paramagnetic materials using electron spin resonance method.
9. To determine the self inductance of a coil by Anderson bridge.
10. Study of different thermocouples for temperature measurement.

Text Books, Reference Books, Other resources

1."B.L. Worsnop and H.T. Flint – Advanced Practical Physics for Students"

2."C.L. Arora – Practical Physics"

3."V.K. Mehta – Principles of Electronics"

4."AjoyGhatak – Optics"

5."Melissinos & Napolitano – Experiments in Modern Physics"

6."S. O. Pillai – Solid State Physics"

7."G.F. Knoll – Radiation Detection and Measurement"

8."S.M. Sze – Physics of Semiconductor Devices"

LAB-2 (PC-12)

1. To calibrate of drum of constant deviation spectrograph.
2. To study the variation of refractive index of the material of prism wavelength and Cauchy's dispersion formula.
3. To determine the wavelength of monochromatic light by diffraction at a straight edge.
4 .To find out the wavelength of the given light source with the help of Michelson interferometer.
5. To determine the angle of a given wedge using given laser beam .
6. To determine the refractive index of water using hollow prism
7. To determine the Plank's constant using Black Body Radiation and PhotoDetector.
8. To determine the absorption lines in the rotational spectrum of Iodine vapour.
9. Determination of Wavelength of different colours using LED.
10. Photo-electric effect: photo current versus intensity and wavelength of light.

Text Books, Reference Books, Other resources

1. AjoyGhatak – Optics
2. E. Hecht – Optics
3. B.L. Theraja – Modern Physics
4. Practical Physics by S. P. Singh
5. Advanced Practical Physics for Students by B.L. Worsnop and H.T. Flint