M.Sc. Course					SC 501T - CLASSICAL MECHANICS & MATHEMATICAL PHYSICS					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	1	0	5	5	25	50	25	--	--	100

COURSE OBJECTIVES

- To develop conceptual understanding of the advanced principles of classical mechanics.
- To appreciate the role of basic methods of classical mechanics towards solutions of various problems of complicated oscillatory systems.
- To familiarize with the motion of rigid bodies, small oscillations and the mechanics of continuous media.
- To introduce to the students basic concepts of finite and infinite groups.
- To learn the Techniques for solving integral equations.
- To enable students to formulate the Green functions.

UNIT 1: CANONICAL TRANSFORMATION **15 Hrs.**

Lagrangian and Hamiltonian for central forces, coupled oscillators and other simple systems, Canonical Variables, Gauge transformation, Canonical transformation, condition for transformations to be Canonical. Generators of infinitesimal canonical transformations, Poission bracket, canonical equations in terms of Poisson bracket notation, Symmetry principles and conservations laws. The Hamilton Jacobi equations, Separation of variables, Action angle variables, Properties of action angle. Centre of mass and laboratory system, Kepler problem.

UNIT 2: THEORY OF SMALL OSCILLATIONS **15 Hrs.**

Small oscillations, Eigen vectors and eigen frequencies, orthogonality of eigen vectors, normal coordinates, small oscillations of particles on string, normal coordinated and its applications to chain molecules and other problems. Degrees of freedom for a rigid body, Euler angles, Rotating frame, Coriolis force, Focault's pendulum, Eulerien coordinates and equations of motion for a rigid body, Symmetries and invariance principles, Noether's theorem, motion of a symmetrical top.

UNIT 3: GROUP THEORY **15 Hrs.**

Elements of finite groups. Representation theory. Group theory: Group, subgroups and classes, cosets, factor groups, normal subgroups, direct product of groups; Examples: cyclic, symmetric, matrix groups, regular n-gon. Mappings: homomorphism, isomorphism, automorphism. Representations: reducible and irreducible representation, unitary representations, Schur's lemma and orthogonality theorems, characters of representation, direct product of representations.

UNIT 4: INTEGRAL EQUATIONS AND GREEN'S FUNCTIONS **15 Hrs.**

Conversion of ordinary differential equations into integral equations, Fredholm and Volterra integral equations, separable kernels, Fredholm theory, eigen values and eigen functions. Boundary Value Problems: boundary conditions: Dirichlet and Neumann; self-adjoint operators, Sturm-Liouville theory, Green's function, eigenfunction expansion.

Max. 60 Hrs.

COURSE OUTCOMES

After completion of this course students will be able to;

CO1: Relate with particle mechanics at an advanced level and utilise the foundations to the classical theory of fields.
CO2: Identify and develop the applications in acoustics, molecular spectra and coupled circuits etc.
CO3: Understand the classification of finite groups in Group theory.
CO4: Apply these concepts in various fields, particularity in crystallography/Physics of solids.
CO5: Describe the analytical techniques for solving integral equations and construct Green's functions for many important boundary value problems.
CO6: Determine the classical mechanics formulation for advanced and specialized courses of Physics.

TEXT/REFERENCE BOOK

1. Mechanics by Landau and Lifshitz
2. Classical Mechanics by Goldstein
3. Classical Mechanics by Rana and Joag
4. Introduction to Classical Mechanics by Takwale R.G. and P. S. Puranik
5. A.W. Joshi, Elements of Group Theory for Physicists
6. M. A. Armstrong, Groups and Symmetry
7. R. S. Kaushal & D. Parashar, Advanced Method of Mathematical Physics

8. M. Hamermesh, Group Theory and Its Applications to Physical Problems
9. F. Albert Cotton, Chemical Applications of Group Theory
10. G. Arfken, H. Weber, & F. Harris, Mathematical Methods for Physicists
11. W. V. Lovitt, Linear Integral Equations (Dover, 2055).
12. J. Jerri, Introduction to Integral Equations with Applications

Course Delivery Methods	
Lecture by use of boards/LCD projectors/OHP projectors	Yes
Tutorials/Assignments	Yes
Seminars	Yes
Mini projects/Projects	No
Laboratory experiments/teaching aids	No
Industrial/guest lectures	Maybe
Industrial visits/in-plant training	No
Self- learning such as use of NPTEL materials and internets	Yes
Simulation	Maybe

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment:

Assessment Tool		% Contribution during CO Assessment	Maximum Marks	Exam Duration
Internal Assessment	Assignment	10 %	-	-
	Quiz	15%	-	-
Examiantion	Mid Semester Examination	25%	50	2 hours
	End Semester Examination	50%	100	3 hours

Assessment Components	CO1	CO2	CO3	CO4	CO5	CO6
Mid Sem Examination Marks	YES	YES	NO	NO	NO	YES
End Sem Examination Marks	YES	YES	YES	YES	YES	YES
Assignment	YES	YES	YES	YES	YES	YES

Indirect Assessment :
1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Programme Outcome				
	PO1	PO2	PO3	PO4	PO5
CO1: Relate with particle mechanics at an advanced level and utilise the foundations to the classical theory of fields.	H	H	M	L	M
CO2: Identify and develop the applications in acoustics, molecular spectra and coupled circuits etc.	M	M	H	L	M
CO3: Understand the classification of finite groups in Group theory.	H	M	M	L	L
CO4: Apply these concepts in various fields, particularity in crystallography/Physics of solids.	M	H	H	M	L
CO5: Describe the analytical techniques for solving integral equations and construct Green's functions for many important boundary value problems.	M	M	H	M	L
CO6: Determine the classical mechanics formulation for advanced and specialized courses of Physics.	M	H	H	L	M

Lecture wise Lesson planning Details:

Week No.	Lect. No.	Unit No.	Topics To be covered	CO Mapped	Remarks by Faculty
1	1	1	Lagrangian for central forces	CO1, CO2	
	2		Hamiltonian for central forces	CO1, CO2	
	3		coupled oscillators and other simple systems	CO1, CO2	
	4		Canonical Variables	CO1, CO2	
2	5		Gauge transformation	CO1, CO2	

	6		Canonical transformation	CO1, CO2, CO6	
	7		Condition for transformations to be Canonical	CO1, CO2, CO6	
	8		Generators of infinitesimal canonical transformations	CO1, CO2, CO6	
3	9		Poission bracket	CO1, CO2, CO6	
	10		Canonical equations in terms of Poisson bracket notation	CO1, CO2	
	11		Symmetry principles and conservations laws	CO1, CO2	
	12		The Hamilton Jacobi equations	CO1, CO2, CO6	
4	13		Separation of variables	CO1, CO2	
	14		Action angle variables, Properties of action angle	CO1, CO2	
	15		Centre of mass and laboratory system	CO1, CO2, CO6	
	16		Kepler problem	CO1, CO2	
5	17	2	Small oscillations	CO1, CO2	
	18		Eigen vectors and eigen frequencies	CO1, CO2, CO6	
	19		Orthogonality of eigen vectors	CO1, CO2, CO6	
	20		Normal coordinates	CO1, CO2, CO6	
6	21		Small oscillations of particles on string	CO1, CO2	
	22		Normal coordinates and its applications to chain molecules and other problems	CO1, CO2, CO6	
	23		Degrees of freedom for a rigid body, Euler angles	CO1, CO2, CO6	
	24		Rotating frame	CO1, CO2	
7	25		Coriolis force	CO1, CO2	
	26		Focault's pendulum	CO1, CO2	
	27		Eulerien coordinates and equations of motion for a rigid body	CO1, CO2	
	28		Symmetries and invariance principles	CO1, CO2, CO6	
8	29		Noether's theorem	CO1, CO2, CO6	
	30		Motion of a symmetrical top	CO1, CO2, CO6	
	31	3	Elements of finite groups	CO3	
	32		Representation theory	CO3	
9	33		Group theory: Group, subgroups and classes	CO3	
	34		Group theory: cosets, factor groups, normal subgroups	CO3	
	35		Direct product of groups	CO3, CO4	
	36		Examples: cyclic, symmetric	CO3, CO4	
10	37		Matrix groups	CO3, CO4	
	38		Regular n-gon	CO3, CO4	
	39		Mappings: homomorphism	CO3, CO4	
	40		Isomorphism, Automorphism	CO3, CO4	
11	41		Representations: reducible and irreducible representation	CO3, CO4	
	42		Unitary representations	CO3, CO4	
	43		Schur's lemma and orthogonality theorems	CO3, CO4	
	44		Characters of representation	CO3, CO4	
12	45		Direct product of representations	CO3, CO4	
	46	4	Conversion of ordinary differential equations into integral equations	CO5	
	47		Fredholm and Volterra integral equations	CO5	
	48		Fredholm and Volterra integral equations	CO5	
13	49		Separable kernels	CO5	
	50		Fredholm theory	CO5	
	51		Eigen values and eigen functions	CO5	
	52		Boundary Value Problems:	CO5	
14	52		Boundary Value Problems:	CO5	
	54		Boundary conditions: Dirichlet and Neumann	CO5	
	55		Boundary conditions: Dirichlet and Neumann	CO5	
	56		Self-adjoint operators	CO5	
15	57		Sturm-Liouville theory	CO5	
	58		Green's function	CO5	

	59		Green's function	CO5	
	60		Eigenfunction expansion	CO5	