St. Philomena's College (Autonomous), Mysore
Question Bank
Programme: M. Sc. Physics
I Semester
Course Title: Classical Mechanics
Course Type: Hard Core
Q.P Code:

Sl.No	Questions	Marks
1.	Define degrees of freedom. Determine the number of degrees of freedom in the following cases. (i) A particle moving on the circumference of a circle. (ii) A rigid body rotating about a fixed axis. (iii) A rigid body moving freely in 3 dimensional space.	4
2.	Set the Lagrangian for Atwood's machine & obtain the Lagrangian equation of Motion for the same.	4
3.	Show that $\ddot{r} = r\omega^2$ for a bead sliding on a rotating wire in a force free space.	4
4.	Write the Lagrangian for spring pendulum system & identify the generalised coordinates.	4
5.	Consider a particle of mass 'm' moving in a plane under the attractive force $\frac{\mu m}{r^2}$ directed to the origin of polar co ordinates(r, θ). Find the Lagrangian & determine the equation of motion.	4
6.	6. Obtain the Lagrangian for Sun-Earth system.	4
7.	Consider the motion of a bead on a rigid parabolic wire ,the shape of which is given by $y = bx^2$. Find the Lagrangian & obtain the equation of motion.	4
8.	Find whether the nature of the force given by the expressions given below is conservative or non conservative: a) $F = (2xy + yz^2)\hat{i} + (x^2 + xz^2)\hat{j} + 2xyz\hat{k}$ b) $F = (yz)\hat{i} + (zx)\hat{j} + xy\hat{k}$	4
9.	In the following cases, discuss whether the constraint is holonomic or non-holonomic. Specify the constraint force also. a Motion of a body on an inclined plane, under gravity. b A bead on a circular wire. c Particle moving on an ellipsoid under the action of gravity	4

d A pendulum of variable length.

10.

11. A particle of mass 'm' constrained to move in a vertical plane along a trajectory given by $x=a\cos\theta, y=a\sin\theta$, where 'a' is a constant. Find the Lagrangian of the particle. 4

12. A cylinder of mass 'M' & radius 'r' , rolls in the x direction from the point x=0 on a horizontal plane without friction. Determine its Lagrangian. 4

13. What are 'Generalised Coordinates? Explain with examples. 5

14. Obtain the Lagrangian equation of motion for a particle of mass 'm' moving in a Plane polar co-ordinate system. 5

15. Find the Lagrangian equation for L-C circuit. 5

16. A particle of mass 'm' moves in a conservative force field. Set the Lagrangian & workout Lagrange's equations of motion in spherical – polar co-ordinate system. 6

17. Define Hamiltonian function and show that Hamiltonian is conserved, if the Lagrangian is not explicit function of time. 6

18. Show that Hamiltonian is conserved if and coordinate q_k is cyclic 6

19. Write Hamilton's equations of motion for a charged particle moving in an electromagnetic field. 6

20. Write the Hamiltonian for a simple pendulum and deduce its equations of motion. 6

21. Describe the Hamiltonian and Hamilton's equations for an ideal spring-mass system. 6

22. Using Hamilton's equation of motion, show that the Hamiltonian $H=\frac{p^2}{2m}e^{-rt}+\frac{1}{2}mw^2x^2e^{rt}$leads to equation of motion of a damped harmonic oscillator $\ddot{x}+r\dot{x}+\omega^2x=0.$ 6

23. Apply variational principle to find the equation of one dimensional harmonic oscillator. 6

24. Justify that degrees of freedom for general motion of rigid body is six. 6

25. write a note on infinitesimal rotations. 6

26. Explain equation's of motion of rigid body for the torque-free case. 6

27. Explain rotation of earth as an example of force free motion of symmetric top. 6

28. Explain stable, unstable and neutral equilibrium with examples. 6

29.	Mention the different types of constraints .Write down the equation of constraints for a particle moving on or outside the surface of a sphere of radius ‘a’.	8
30.	Obtain the equation of motion of simple pendulum using Lagrangian formulation.	8
31.	Obtain Lagrangian equation from Hamilton’s principle.	8
32.	Discuss Generalized momentum and cyclic coordinates.	9
33.	For the case of motion of a particle in a central field, show that generalized momentum is conserved.	9
34.	If the translation coordinate q_k is cyclic, show that linear momentum is conserved.	9
35.	If the rotation coordinate q_k is cyclic, show that angular momentum is conserved.	9
36.	Obtain Hamilton’s equations in Cartesian coordinate system.	9
37.	Obtain Hamilton’s equations in Polar coordinate system.	9
38.	Obtain Hamilton’s equations in cylindrical coordinate system.	9
39.	Obtain Hamilton’s equations in spherical coordinate system.	9
40.	Write Hamilton’s equations of motion for harmonic oscillator.	9
41.	Write Hamilton’s equations for motion for compound pendulum.	9
42.	Write Hamilton’s equations of motion for two dimensional harmonic oscillator in Cartesian coordinates.	9
43.	Write Hamilton’s equations of motion for two dimensional harmonic oscillator in Polar coordinates.	9
44.	Obtain the Lagrangian, Hamiltonian and equations of motion for a projectile near the surface of the earth.	9
45.	Describe the motion of a particle of mass m constrained to move on the surface of the cylinder of radius a and attracted towards the origin by a force which is proportional to the distance of the particle from the origin.	9
46.	Define canonical transformations and discuss Legendre transformations for transformation of basis from set of coordinates (x, y) to (u, v).	9
47.	Discuss the concept of generating function under canonical transformations and mention the four forms of generating functions.	9
48.	Discuss any two forms of generating functions.	9
49.	Discuss the procedure and condition for the application of canonical transformations.	9

50. Discuss harmonic oscillator as an example of canonical transformations. 9

51. Write a note on infinitesimal contact transformations. 9

52. The motion of the system during an interval of time may be regarded as infinitesimal contact transformation generated by Hamiltonian, Explain . 9

53. Define Poisson bracket and show that a function whose Poisson bracket vanishes is a constant of motion. 9

54. Discuss properties of Poisson bracket and arrive at fundamental Poisson brackets. 9

55. Obtain the Poisson bracket relations of linear and angular momentum . 9

56. Discuss invariance of Poisson bracket with respect to canonical transformations. 9

57. Show that transformation defined by $q=\sqrt{2P}\,SinQ$ and $p=\sqrt{2Q}\,CosQ$ is canonical by using Poisson bracket. 9

58. Obtain Jacobi's identity. 9

59. Discuss Hamilton-Jacobi equation. 9

60. Obtain the solution of Harmonic oscillator by Hamilton-Jacobi method. 9

61. Show that [L]=[I][ω] for a rigid body rotating about a fixed point in the body. 9

62. Define principle axis of the rigid body and discuss principle moment of inertia. 9

63. Discuss rotational kinetic energy of a rigid body. 9

64. Discuss moment of inertia for different body systems. 9

65. Discuss Euler's equations of motion for rigid body by Newtonian method. 9

66. Discuss Euler's equations of motion for rigid body by Lagrange's method. 9

67. Obtain coupled differential equations and corresponding solution for two coupled oscillators. 9

68. Discuss normal coordinates and normal modes, symmetric and anti symmetric modes for the system of two coupled oscillators. 9

69. Discuss two coupled pendulum as an example of two coupled oscillators. 9

70. Discuss double pendulum as an example of two coupled oscillators. 9

71. State & explain D'Alembert's principle & principle of virtual work. 10

72. What are forces of constraints? Explain the difficulties introduced by the Constraints and their removal. 10

73. Obtain Lagrangian equations of motion for a particle of mass 'm' moving in cylindrical polar coordinate & Cartesian coordinate system. 10

74. Determine Lagrangian for a charged particle moving in an electromagnetic field. 10

75. Starting from D'Alembert's principle obtain Lagrange's equation of motion for the conservative system. 10

76. Obtain Jacobi's integral, when the Lagrangian is not explicit function of time. 12

77. Obtain Hamilton's equations of motion. 12

78. Write Hamilton's equations for motion of a particle in central force field. 12

79. Deduce Euler-Lagrange equations from variational principle . 12

80. Define space and body coordinate systems and obtain the mathematical relations to show that degrees of freedom for general motion of rigid body is six. 12

81. Discuss Euler angles. 12

82. Discuss geometrical description of the motion of rigid body for the torque-free case. 12

83. Deduce equation of motion for one dimensional oscillator, for small displacement from the equilibrium. 12