Dept. of Physics, Bangabasi College Kolkata, NPTEL Local Chapter

M.C.Q Assignments on CC-2 Classical Mechanics

1. A particle moves in a straight line such that it's velocity is given by $v^2 = \mu(a/x - 1)$, where x is the distance from a fixed point. The acceleration is proportional to
   a) 1/x away from fixed point
   b) -1/x towards a fixed point
   c) $1/x^2$ away from the fixed point
   d) $-1/x^2$ towards the fixed point.

2. If $x=30t-2t^2$, where x is in cm & t is sec, the average velocity between t=5 to 5.01s will be
   a) 8cm/s
   b) b) 9cm/s
   c) 9.98cm/s
   d) d) 0cm/s

3. A particle is moving in a straight line subject to a resistance which produces a deceleration of kv3, k being a constant, v & u are instantaneous & initial velocities respectively, x is distance moved. Then v is equal to
   a) Mu/(M+kxu)
   b) Mk/(M+kxu)
   c) Mx/(M+kxu)
   d) M/(M+kxu)

4. A particle is moving once around a circle in the X-Y plane, with centre at origin & radius=3 units. If the force field is given by $\vec{F} = (2x - y + z)\hat{i} + (x + y - z^2)\hat{j} + (3x - 2y + 4z)\hat{k}$. The work done by the particle will be
   a) 0
   b) π
   c) 18π
   d) π/2

5. If $\vec{F} = (2xy + z^3)\hat{i} + x^2\hat{j} + 3xz^2\hat{k}$ be a conservative force field, the potential function V(x,y,z) can be written as
   a) $-x^2y-xz^3$+const.
   b) $-x^2y$+const.
   c) $-xz^3$+const.
   d) $-2x^2y-2xz^3$+const.

6. A particle of mass 2 moves in the xy-plane under the influence of a force field having potential $V=x^2+y^2$. The particle starts at a time t=0 from rest at the point (2,1). The values of $x(t)$ and $y(t)$ will be
a) cos t and 2cos t respectively
b) 2cos t and sin t respectively
c) cos t and 2sin t respectively
d) 2cost and cos t respectively

7. A particle is attracted towards a fixed point with a force F(x) ∝ $1/x^3$, where x is the distance from the fixed point. Find an expression for the work done for a displacement of a to b (a<b). The P.E. gained by the particle is
a) $-\mu/2\ [1/a^2 - 1/b^2]$
b) $-\mu/2\ [1/b^2 - 1/a^2]$
c) $-\mu/2\ [1/a^2 + 1/b^2]$
d) $\mu/2\ [1/a^2 + 1/b^2]$

8. A particle is thrown upward with speed V. The air resistance be equal to mkv^2. If air resistance is assumed to be equal to gravitational pull at a speed U (i.e. at the point where the net force on the particle is zero), the particle will rise for a time
a) $t = (U/g)\tan^{-1}(V/U)$
b) $t = (V/g)\tan^{-1}(V/U)$
c) $t = (U/g)\tan^{-1}(U/V)$
d) $t = (g/U)\tan^{-1}(V/U)$

9. A steel ball ($\rho = 7.8\times10^3$kg/m^3) of radius r = 2 mm is falling through glycerine (η=0.83 Pa.s, $\sigma = 1.2 \times 10^3$kg/m^3). Its terminal velocity will be
a) 0.01 m/s
b) 0.05 m/s
c) 0.07 m/s
d) 1.00 m/s

10. A particle is projected vertically upward with initial speed equal to tan α times the terminal speed, the resistance being proportional to the square of the speed. The particle hits the ground with speed
a) tan α times the terminal speed
b) sin α times the terminal speed
c) cos α times the terminal speed
d) 0

11. A rocket set for vertical launching, weighs 50 kg and contains 450 kg of fuel. It can have a maximum exhaust velocity of 2 km/s. What should be the rate of consumption of fuel so that the rocket starts with an initial acceleration of 20 m/s^2 ?

a) 1.45 kg/s
b) 3.45 kg/s
c) 5.45 kg/s
d) 7.45 kg/s

12. A rocket starting initially from rest, with u equal to 2.1 km/s and a mass loss per second equal to 1/60th of the initial mass, that in order to reach the escape velocity the ratio of the weight of the fuel to the weight of the empty rocket must be approximately

a) 275:1
b) 65:1
c) 860:1
d) 1120:1

13. If a particle is moving under central force field, then which one of the following is true?

a) the particle moves in a straight line
b) motion of the particle is confined in a plane
c) angular momentum of the particle is conserved
d) both (b) and (c) are true

14. Which of the following condition is true if a particle is moving under central force field?

a) E >, < and = 0 correspond to the path is an ellipse, a parabola and a hyperbola respectively
b) E >, < and = 0 correspond to the path is a parabola, an ellipse and a hyperbola respectively
c) E >, < and = 0 correspond to the path is a hyperbola, an ellipse, and a parabola respectively
d) E >, < and = 0 correspond to the path is an an ellipse, a hyperbola and a parabola respectively.

15. A rocket has an initial mass of m and a burn rate of –dm/dt. What is the minimum exhaust velocity that will allow the rocket to lift off immediately after firing (assuming $\alpha = -dm/dt$)?

a) $2g/\alpha$
b) $2g/3\alpha$
c) g/α
d) $g/2\alpha$

16. A spherical rain drop falling under constant gravity and its radius at any instant t is given by $r=kt/\rho$. The rate of increase of its mass is proportional to the instantaneous surface area. The velocity (v) at any instant t is

a) gt/2

b) gt/3
c) gt/4
d) gt/5

17. If $\vec{F} = \frac{r(r-1)}{(r^2+1)}\hat{r}$ represent a central force field. Which one of the following is true?
a) it is attractive in nature
b) it is repulsive in nature
c) attractive if 0<r<1 and repulsive if r>1
d) repulsive if 0<r<1 and attractive if r>1

18. Which of the followings can be central force field?
a) Lorentz magnetic force
b) Lorentz electric force
c) Frictional force
d) Viscous force

19. The potential corresponding to the central force field $\vec{F} = \left(\frac{\alpha}{r^2} + \frac{\beta}{r^3}\right)\hat{r}$ is given by
a) 0
b) $\alpha/r + \beta/r^2$
c) $2\alpha/r + 3\beta/r^2$
d) $\alpha/r + \beta/2r^2$

20. For a motion under the central force $-k/r^3$, if a particle of mass m starts on the positive X-axis at a distance 'a' away from the origin and moves with speed v_0 in direction making an angle α with X-axis, the differential equation of motion can be written as
a) $\frac{d^2r}{dt^2} = -\frac{k - ma^2v_0^2\sin^2\alpha}{mr^3}$ (CORRECT)
b) $\frac{d^2r}{dt^2} = \frac{k - ma^2v_0^2\sin^2\alpha}{mr^3}$
c) $\frac{d^2r}{dt^2} = -\frac{k + ma^2v_0^2\sin^2\alpha}{mr^3}$
d) $\frac{d^2r}{dt^2} = \frac{k + ma^2v_0^2\sin^2\alpha}{mr^3}$

21. If a particle described by an attractive central force moves in an orbit given by r = acos(θ), the law of force is proportional to
a) $1/r^2$
b) $1/r^3$
c) $1/r^4$
d) $1/r^5$

22. A particle describes an equiangular spiral $r = ae^{\theta}$ in such a manner that its acceleration has no radial component. Then,

a) angular velocity is zero
b) angular velocity is constant and magnitude of velocity is proportional to r
c) angular velocity is constant and magnitude of velocity is proportional to 1/r
d) angular velocity and magnitude of velocity is proportional to r.

23. For attractive inverse square force field $f(r) = -k/r^2$, show that the velocity at any point of the for n hyperbolic path may be given as

a) $v^2 = k/m\ [2/r - 1/a]$
b) $v^2 = k/m\ [2/r + 1/a]$
c) $v^2 = m/k\ [2/r - 1/a]$
d) $v^2 = m/k\ [2/r + 1/a]$

24. A small satellite revolves around a planet in an orbit of radius slightly greater than the radius R of the planet, which is spherical. If the average density of the planet is ρ, the period of revolution of satellite

a) independent of R of the planet
b) depends on R^2 of the planet
c) depends on R^3 of the planet
d) depends on R^4 of the planet

25. The central force necessary to make a particle describe the lemniscate $r^2=a^2 \cos 2\theta$ is

a) proportional to r^7
b) inversely proportional to r
c) proportional to r
d) inversely proportional to r^7

26. If a particle describes an elliptic orbit under the influence of an attractive central force $-k/r^2$, then the period of revolution of the particle is

a) $2\pi a^{3/2} \sqrt{(m/k)}$
b) $2\pi a^{3/2} \sqrt{(k/m)}$
c) $\pi a^{3/2} \sqrt{(m/k)}$
d) $\pi a^{3/2} \sqrt{(k/m)}$

27. Find the law of force to the pole when the orbit described by the cardioid $r=a(1-\cos\theta)$

a) proportional to r^{-1}
b) proportional to r^{-2}
c) proportional to r^{-3}
d) proportional to r^{-4}

28. Which one is the correct expression of areal velocity?

a) $r^2\dot{\theta}/2$ (CORRECT)
b) $r^2\dot{\theta}$

c) $r^2\dot{\theta}^2/2$
d) $\dot{r}^2\dot{\theta}/2$

29. A ballistic missile is launched from earth's surface. If the angular range of the missile is 2φ, the physical distance between the launching point and point of impact is
a) $R_0\varphi$ b) $2R_0\varphi$ c) $3R_0\varphi$ d) $4R_0\varphi$

30. Areal velocity of central orbit is proportional to
a) Speed at any point of the orbit
b) Angular acceleration at any point of the orbit
c) Angular velocity at any point of the orbit
d) Angular momentum

31. If gravitational force between two bodies had been inversely proportional to the third power of the distance between them, find out the escape velocity at the surface of the earth.
a) √(2gR)
b) √(12gR)
c) √(23gR)
d) √(gR)

32. A satellite moves in an elliptic path with the earth at one focus. At the perigee (nearest point) its speed is v and its distance from the centre of the earth is r. If ϵ=0.5, what is its speed at the apogee (farthest point)?
a) v
b) v/2
c) v/3
d) 2v

33. The greatest and least velocities of a certain planet in its orbit around the sun are 30.0 and 29.2 km/s. The eccentricity of the orbit is
a) 0.013
b) 0.05
c) 0.49
d) 1.00

34. A binary star is formed when two stars bound by gravity move around a common centre of mass. Each component of a binary star has period of revolution about their centre of mass, equal to 14.4 days and the velocity of each component of 220 km/s. Further, the orbit is nearly circular. Calculate the separation of the two components.
a) 5.5×10^{10} m
b) 8.7×10^{10} m
c) 9.5×10^{10} m
d) 2.9×10^{10} m

35. If a satellite has its largest and smallest speeds given by v_{max} and v_{min}, respectively, and has time period equal to T and it moves on an elliptic path. Calculate the semi-major axis 'a' is given as

a) $T/2\pi\ (v_{max}\ v_{min})^{1/2}$
b) $T/2\pi\ (v_{max}\ v_{min})^{1/3}$
c) $2\pi/T\ (v_{max}\ v_{min})^{1/2}$
d) $2\pi/T\ (v_{max}\ v_{min})^{1/3}$

36. A satellite of radius a revolves in a circular orbit about a planet of radius b with period T. If the shortest distance between their surfaces is c, the mass of the planet is

a) $\frac{4\pi^2(a+b-c)^3}{GT^2}$
b) $\frac{4\pi^2(a+b+c)^3}{GT^2}$ (CORRECT)
c) $\frac{4\pi^2(a-b+c)^3}{GT^2}$
d) $\frac{4\pi^2(a+b+c)^3}{GT}$

37. Assuming that the earth is a sphere of radius 6400 km, with what velocity must a projectile be fired from the earth's surface in order that its subsequent path be an ellipse with major axis equal to 80,000 km?

a) ~2 km/s
b) ~5 km/s
c) ~8 km/s
d) ~10 km/s

38. A satellite has an elliptic orbit with the perigee (nearest point) of r_p = 6570 km and apogee (farthest point) at r_a = 42,250 km. The perigee velocity was v_p = 10.25 km/s. Angular momentum of the satellite at apogee is approximately

a) 55342.5 Kg.m2/sec
b) 87342.5 Kg.m2/sec
c) 67342.5 Kg.m2/sec
d) 97342.5 Kg.m2/sec

39. A particle of mass m moves under the action of a central force whose potential is $V(r)=kmr^2$ (k>0). For what angular momentum the orbit will be a circle of radius 'a' about the origin?

a) $\sqrt{(3k)}\ ma^{5/2}$
b) $\sqrt{(3k)}\ ma^{3/2}$
c) $\sqrt{(3km)}\ a^{5/2}$
d) $\sqrt{(3km)}\ a^{3/2}$

40. The effective P.E. of a particle in a central force field is given by $V' = V(r) + (L^2/2mr^2)$. If the central potential is $1/2kr^2$, the angular frequency (ω) for circular orbit is
a) √(m/k)
b) √(m/2k)
c) √(2m/k)
d) √(k/m)

41. A particle moving in a central force field located at r=0 describes the spiral $r=e^{-\theta}$. The law of force is a) $\propto 1/r$ b) $\propto 1/r^2$ c) $\propto 1/r^3$ d) $\propto 1/r^5$

42. What will be the approximate time for one rotation for the plane of oscillation of the Foucault pendulum at 30°N latitude?
a) 48 hr
b) 36 hr
c) 24 hr
d) 12 hr

43. What will be the horizontal component of the Coriolis force acting on a body of mass 1.5 kg moving northward with a horizontal velocity of 100 m/sec, at 30°N latitude on earth?
a) 0.5 N along east
b) 0.0109 N along east
c) 0.9201 N along east
d) 0 N

44. Two separate Foucault pendulum experiments were set up on same longitude 10,466 km apart from each other. The plane of one pendulum was seen to rotate clockwise at a time period of 27.6 hrs. The plane of other pendulum was seen to rotate anticlockwise direction with time period 42.9 hrs. From this data, approximate radius of the earth is
a) 6350 km
b) 6787 km
c) 6024 km
d) 6991 km

45. Given that earth rotates once every 23 hr 56 min around the axis from the North to South Pole, calculate the angular velocity, ω, of the earth.
a) 7.29×10^{-3} rad/sec
b) 51.21×10^{-5} rad/sec
c) 7.29×10^{-5} rad/sec
d) 17.84×10^{-4} rad/sec

46. An iceberg of mass 5×10^5 tons near the North Pole moves west at the rate of 8 km/day. Neglecting the curvature of the earth, calculate the magnitude and direction of the Coriolis force.

a) 6730 N and north
b) 6730 N and south
c) 6730 N and east
d) 6730 N and west

47. A train of mass 1000 tons moves in the latitude 60° north. Find the magnitude and direction of the lateral force that the train exerts on the rails if it moves with a velocity of 15 m/s

a) ~2560 N and on the right rail
b) ~1890 N and on the left rail
c) ~2560 N and on the left rail
d) ~1890 N and on the right rail

48.

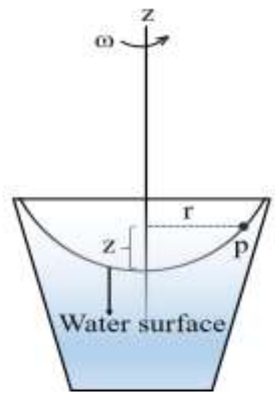
A bucket full of water spins with angular velocity $\vec{\omega}$ about the axis as shown in the figure. The shape of the water surface is given by

a) $z = \omega^2 r^2 /2g$

b) $z = \omega^2 g^2 /2r$

c) $z = \omega^2 r^2 /2g^2$

d) $z = \omega^2 r^2 /3g$



49. A body is thrown vertically upwards with a velocity of 100 m/s at a 60° latitude. The displacement from the vertical in 10sec is

a) 24.5 cm on the west
b) 24.5 cm on the east
c) 24.5 cm on the north
d) 24.5 cm on the south

50. A quadrilateral ABCD has masses 1, 2, 3 and 4 units located at its vertices A(-1, -2, 2), B(3, 2, -1), C(1, -2, 4) and D(3, 1, 2). The center of mass is at

a) (2, 0, 2)
b) (2, 0, -2)
c) (-2, 0, 2)
d) (-2, 0, -2)

51. Three particles of masses 2, 1, 3 units respectively have position vectors $\vec{r}_1 = 5t\hat{i} - 2t^2\hat{j} + (3t-2)\hat{k}$, $\vec{r}_2 = (2t-3)\hat{i} + (12-5t^2)\hat{j} + (4+6t-3t^3)\hat{k}$ and $\vec{r}_3 = (2t-1)\hat{i} + (t^2+2)\hat{j} - t^3\hat{k}$ where t is the time. The velocity of center of mass at t=1sec will be

a) i^−j^−k^
b) 3i^−2j^+k^
c) 3i^+2j^−k^
d) 3i^−2j^−k^

52. The centre of mass of a uniform semi-circular wire of radius a, having origin as centre of curvature, is situated along the y-axis, at a distance

a) $a/2\pi$

b) $3a/2\pi$

c) a/π

d) $2a/\pi$

53. Two particles having masses m1 and m2 move so that their relative velocity is v and the velocity of their center of mass is V. If M is the total mass and μ is the reduced mass of the system, the total kinetic energy is given by

a) $Mv^2/2 + \mu V^2/2$

b) $MV^2/2 + \mu v^2/2$

c) $Mv^2/2 - \mu V^2/2$

d) $(M+\mu)V^2/2$

54. A tri-atomic molecule is moving in a space such that distance between any two of them is always constant. Degrees of freedom of the system is

a) 3

b) 5

c) 6

d) 7

55. The centre of mass of a semi-circular plate of radius a, centred at the origin, is at a distance along the Y-axis

a) $4a/3\pi$

b) $a/3\pi$

c) $3a/4\pi$

d) $4a/\pi$

56. The moment of inertia of a right circular cone of height h and radius a about its axis is given by

a) $2Ma^2/5$

b) $3Ma^2/10$

c) $Ma^2/10$

d) $7Ma^2/10$

57. Two particles of masses m_1 and m_2 are connected by a rigid massless rod of length a and can move freely in a plane. The moment of inertia of the system, provided that the reduced mass is μ, about an axis perpendicular to the plane and passing through centre of mass is given by

a) $\mu a^2/2$

b) $2\mu a^2/3$

c) $2\mu a^2/5$

d) μa^2

58. Moment of inertia of a uniform square plate of length x=y=a and mass M about x and y axes are
 a) $I_{xx} = Ma^2/3$ and $I_{yy} = Ma^2/3$
 b) $I_{xx} = 2Ma^2/3$ and $I_{yy} = 2Ma^2/3$
 c) $I_{xx} = Ma^2/3$ and $I_{yy} = 2Ma^2/3$
 d) $I_{xx} = 2Ma^2/3$ and $I_{yy} = Ma^2/3$

59. For the above consideration, Moment of inertia about the z axis is given by
 a) $Ma^2/3$ b) $3Ma^2/2$ c) Ma^2 d) $2Ma^2/3$

60. Products of inertia of a uniform square plate of length x=y=a and mass M are
 a) $I_{xy} = I_{yx} = 0$, $I_{xz} = I_{zx} = 0$ and $I_{yz} = I_{zy} = 0$
 b) $I_{xy} = I_{yx} = -Ma^2/4$, $I_{xz} = I_{zx} = 0$ and $I_{yz} = I_{zy} = 0$
 c) $I_{xy} = I_{yx} = 0$, $I_{xz} = I_{zx} = -Ma^2/4$ and $I_{yz} = I_{zy} = -Ma^2/4$
 d) $I_{xy} = I_{yx} = 0$, $I_{xz} = I_{zx} = -Ma^2/4$ and $I_{yz} = I_{zy} = 0$

61. Principal moment of inertia of a uniform square plate of length x=y=a and mass M are
 a) $I_1 = 0$, $I_2 = 0$ and $I_3 = 0$
 b) $I_1 = Ma^2/12$, $I_2 = 0$ and $I_3 = 7Ma^2/12$
 c) $I_1 = Ma^2/12$, $I_2 = 7Ma^2/12$ and $I_3 = 0$
 d) $I_1 = Ma^2/12$, $I_2 = 7Ma^2/12$ and $I_3 = 2Ma^2/3$

62. Moment of inertia of a solid circular plate of radius a, height h and mass M about an axis on the surface of the cylinder and parallel to the axis of the cylinder is
 a) Ma^2
 b) $2Ma^2/3$
 c) $3Ma^2/2$
 d) $Ma^2/2$

63. Radius of gyration of a rectangular plate with sides a and b about an axis perpendicular to the plate and passing through a vertex is
 a) $M(a^2+b^2) / 3$
 b) $[(a^2+b^2) / 3]^{1/2}$
 c) $[M(a^2+b^2) / 3]^{1/2}$
 d) $(a^2+b^2) / 3$

64. Calculate the radius of gyration of a spherical shell of mass M and radius R with origin (fixed point) at its centre
 a) $\sqrt{3}R/8$
 b) $\sqrt{2}R/5$
 c) $\sqrt{2}R/3$
 d) $\sqrt{3}R/5$

65. A solid cylinder of radius a and mass M rolls without slipping down an inclined plane of angle θ. The acceleration is

a) $g\sin\theta$ b) $g\sin\theta/3$ c) $2g\sin\theta/3$ d) $2\sin\theta/3$

66. Equation for the ellipsoid of inertia corresponding to a square plate of length x=y=a is

a) $x^2 + y^2 + 2z^2 - 3xy/2 = 3/Ma^2$

b) $x^2 + y^2 + 2z^2 + 3xy/2 = 3/Ma^2$

c) $x^2 - y^2 - 2z^2 - 3xy/2 = 3/Ma^2$

d) $x^2 + y^2 + 2z^2 - 3xy/2 = -3/Ma^2$

67. I) For a sphere, if $I_1 = I_2 = I_3$, it means that

a) the angular velocity ($\vec{\omega}$) is non zero but the angular momentum ($\vec{L}$) is zero

b) the angular velocity ($\vec{\omega}$) is perpendicular to the angular momentum ($\vec{L}$)

c) the angular velocity ($\vec{\omega}$) is zero but the angular momentum ($\vec{L}$) is non-zero

d) the angular velocity ($\vec{\omega}$) is parallel to the angular momentum($\vec{L}$)

67 II). During the discussion of torque free motion of a symmetric top, we have considered two constants of motion. One of them was the rotational kinetic energy of the system. The other one is

a) Total angular momentum

b) space z-component of angular momentum

c) Total energy of rotation

d) body z-component of angular momentum

68. Stable spinning of a symmetric top may be achieved

a) For rotation around an axis with either highest or lowest M.O.I

b) For rotation about any arbitrary axis

c) For any axis passing through C.M.

d) For any rotation velocity perpendicular to horizontal direction

69. If N_1, N_2, N_3 and ω_1, ω_2, ω_3 are the respective components of the external torque and angular velocity along the principle axes, then one of the true equation of motion is

a) $I_1\dot{\omega}_1 + (I_1 - I_2)\omega_2\omega_3 = N_1$

b) $I_2\dot{\omega}_2 + (I_1 - I_2)\omega_1\omega_3 = N_2$

c) $I_2\dot{\omega}_1 + (I_1 - I_2)\omega_2\omega_3 = N_2$

d) $I_1\dot{\omega}_1 + (I_3 - I_2)\omega_2\omega_3 = N_1$

70. If T be the kinetic energy, $\vec{N}$ be the external torque about the instantaneous axis of rotation and $\vec{\omega}$ is the angular velocity, then which relation of the following is true?

a) $dT/dt = \vec{N}\cdot\vec{\omega}$

b) $dT/dt = |\vec{N}\times\vec{\omega}|$

c) $dT/dt = N\omega^2/2$

d) $\vec{N}\cdot\vec{\omega} = \text{constant}$