CBSE

SYSTEM OF PARTICLES AND ROTATIONAL MOTION WS 6

Class 11 - Physics

Section A

1. Angular momentum is **[1]**

   a) product of mass and angular velocity
   b) moment of angular motion
   c) product of M.I. and velocity
   d) moment of momentum

2. Which is a vector quantity? **[1]**

   a) Angular momentum
   b) Electric current
   c) Work
   d) Potential energy

3. A wheel is rotating about an axis through its centre at 720 r.p.m. When acted upon by a constant torque opposing its motion for 8 seconds it stops rotating. The value of this torque in Nm is (given I = $\frac{24}{\pi}$ kg m^2) **[1]**

   a) 72
   b) 48
   c) 96
   d) 120

4. A force $\vec{F} = \alpha\hat{i} + 3\hat{j} + 6\hat{k}$ is acting at a point $\vec{r} = 2\hat{i} - 6\hat{j} - 12\hat{k}$. The value of α for which angular momentum about origin is conserved, is **[1]**

   a) 2
   b) zero
   c) -1
   d) 1

5. The torque $\vec{\tau}$ on a body about a given point is found to be equal to $\vec{A} \times \vec{L}$, where $\vec{A}$ is a constant vector and $\vec{L}$ is the angular momentum of the body about that point. From this it follows that **[1]**

   a) the magnitude of $\vec{L}$ does not change with time.
   b) all of these
   c) $\frac{d\vec{L}}{dt}$ is perpendicular to $\vec{L}$at all instants of time
   d) the component of $\vec{L}$ *[Math Processing Error]* in the direction of $\vec{A}$ does not change with time

6. Which one is a vector quantity? **[1]**

   a) Both of torque and energy
   b) Energy
   c) Work
   d) Torque

7. Joule second is the unit of **[1]**

   a) angular momentum
   b) pressure
   c) work
   d) momentum

8. Under a constant torque, the angular momentum of a body changes from A to 4 A in 4 sec. The torque on the body will be **[1]**

a) $\frac{4}{3}A$ b) $\frac{3}{4}A$

c) $\frac{1}{4}A$ d) 4 A

9. A thin uniform rod of length 2l and mass M is acted upon a constant torque. The angular velocity changes from zero to ω in time t. The value of torque is: **[1]**

a) $\frac{Ml^2\omega}{3t}$ b) $\frac{2Ml^2\omega}{3t}$

c) $\frac{Ml^2\omega}{12t}$ d) $\frac{Ml^2\omega}{t}$

10. In a bicycle the radius of rear wheel is twice the radius of the front wheel. If r_f and r_r are the radii v_f, and v_r are the speeds of topmost points of wheels, then **[1]**

a) $v_f > v_r$ b) $f = 2v_r$

c) $v_f = v_r$ d) $v_r = 2v_f$

11. If force acts on a body, whose line of action does not pass through its centre of gravity, then the body will experience **[1]**

a) linear acceleration b) angular acceleration

c) both angular acceleration and linear acceleration d) Non-linear acceleration

12. **Assertion (A):** It is harder to open and shut the door if we apply force near the hinge. **[1]**
Reason (R): Torque is maximum at hinge of the door.

a) Both A and R are true and R is the correct explanation of A. b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false. d) A is false but R is true.

13. **Assertion:** A ladder is more apt to slip when you are high up on it than when you just begin to climb. **[1]**
Reason: At the high upon a ladder the torque is large and on climbing up the torque is small.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion. b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement. d) Assertion is wrong statement but reason is correct statement.

14. **Assertion (A):** A helicopter must necessarily have two propellers. **[1]**
Reason (R): Two propellers are provided in a helicopter in order to conserve linear momentum.

a) Both A and R are true and R is the correct explanation of A. b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false. d) A is false but R is true.

15. **Assertion (A):** Torque on a body can be zero even if there is a net force on it. **[1]**
Reason (R): Torque and force on a body are always perpendicular.

a) Both A and R are true and R is the correct explanation of A. b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false. d) A is false but R is true.

16. **Assertion (A):** If a satellite is orbiting around a planet, then its angular momentum is conserved. **[1]**

Reason (R): Linear momentum conservation leads to angular momentum conservation.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

17. **Assertion (A):** There is no difference between the moment of force and work since they have the same dimension. **[1]**

Reason (R): Dimension of the moment of force and work is $[ML^2I^{-2}]$.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

18. **Assertion:** A particle is moving with constant speed on a straight line in XY plane. Its angular momentum about origin is constant. **[1]**

Reason: The moment of momentum is Zero when particle moves with uniform velocity.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

19. **Assertion:** Many great rivers flow toward the equator. The sediments that they carry increases the time of rotation of the earth about its own axis. **[1]**

Reason: The angular momentum of the earth about its rotation axis is conserved.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

20. **Assertion (A):** Power associated with torque is the product of torque and angular speed of the body about the axis of rotation. **[1]**

Reason (R): Torque in rotational motion is analogue to force in translatory motion.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

21. **Assertion (A):** The angular velocity of planets orbiting around the sun increases when they are nearest to the sun. **[1]**

Reason (R): The angular momentum of body is proportional to angular velocity.

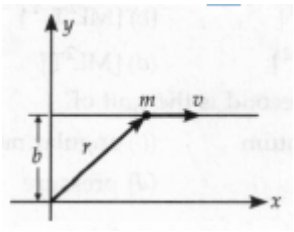
a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

22. A particle of mass m is moving with a constant velocity v parallel to x-axis in an x-y plane as shown in the figure. **[1]**



Calculate angular momentum with respect to origin at any instant.

a) zero

b) -mvb$\hat{k}$

c) $\frac{mvb}{2}\hat{k}$

d) mvbcos$\theta\hat{k}$

23. Identify the vector quantity among the following: **[1]**

a) angular momentum

b) distance

c) energy

d) heat

24. A planet revolves around the sun under the effect of the gravitational force exerted by the sun. Why is the torque on the planet due to the gravitational force zero? **[1]**

25. Find the torque of a force $7\hat{\mathbf{i}} + 3\hat{\mathbf{j}} - 5\hat{\mathbf{k}}$ about the origin. The force acts on a particle whose position vector is $\hat{\mathbf{i}} - \hat{\mathbf{j}} + \hat{\mathbf{k}}$. **[1]**

26. Why it is easier to open a tap with two fingers than with one finger? **[1]**

27. A body is rotating at a steady rate. Is any torque acting on the body? **[1]**

28. Under what conditions, is the torque zero? **[1]**

29. Why a wrench of longer arm is preferred in comparison to a wrench of a shorter arm? **[1]**

30. Which component of a force does not contribute towards torque? **[1]**

31. Write the dimensional formula of angular momentum. Is it a scalar? **[1]**

Section B

32. A constant torque is acting on a wheel. If starting from rest, the wheel makes n rotations in t second, show that the angular acceleration is given by $\alpha = \frac{4\pi n}{t^2}$ rads^{-2}. **[2]**

33. If a constant torque of 500 Nm turns a wheel of moment of inertia 100 kg m^2 about an axis through its centre, find the gain in angular velocity in 2 s. **[2]**

34. Define the term torque or moment of force. Give its units and dimensions. **[2]**

35. How can you define moment of inertia of a rotating body in terms of its **[2]**

i. angular momentum

ii. torque?

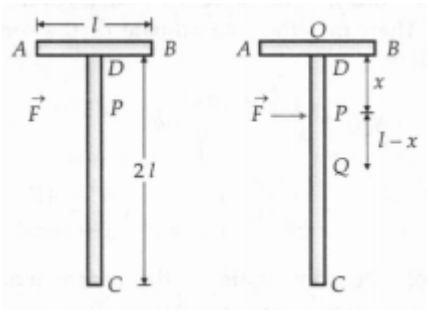
36. There is a stick half of which is wooden and half is of steel. It is pivoted at the wooden end and a force is applied at the steel end at right angles to its length. Next, it is pivoted at the steel end and the same force is applied at the wooden end. In which case is the angular acceleration more and why? **[2]**

37. Torque and work are both equal to force times distance. Then how do they differ? **[2]**

38. Find the torque of a force $7\hat{i} - 3\hat{j} - 5\hat{k}$ about the origin which acts on a particle whose position vector is $\hat{i} + \hat{j} - \hat{k}$. **[2]**

39. Although both torque and work are defined as force multiplied by distance, they differ in there physical meaning. Why? **[2]**

40. A T-shaped object with dimensions shown in Fig. is lying on a smooth floor. A force F is applied at the point P parallel to AB, such that the object has only the translational motion without rotation. Find the location of P with respect to C. **[2]**



41. In a hydrogen atom, the electron revolves in a circular orbit of radius 0.53 $\mathring{A}$ with a velocity of 2.2 $\times 10^6$ m/s with an angle 30°. If the mass of electron is 9 $\times$ 10^{-31} kg. Find its angular momentum. **[2]**

42. The moment of inertia of a body is 2.5 kg m^2. Calculate the torque required to produce an angular acceleration of 18 rad s^{-2} in the body. **[2]**

43. Show that the angular momentum of a satellite of mass M_s revolving around the earth having mass M_e in an orbit of radius r is $L = \sqrt{GM_eM_s^2r}$. **[2]**

44. Find the moment about the point (1, -1, -1) of the force $3\hat{i} + 4\hat{j} - 5\hat{k}$ acting at the point (1, 0, -2). **[2]**

45. What is a couple? What effect does it have on a body? Show that moment of couple is same irrespective of the point of rotation of the body. **[2]**

46. Using expressions for power and kinetic energy of rotational motion, derive the relation, τ=Iα, where letters have their usual meanings. **[2]**

47. The vector sum of a system of non-collinear forces acting on a rigid body is given to be non-zero. If the vector sum of all the torques due to the system of forces about a certain point is found to be zero, does this mean that it is necessarily zero about any arbitrary point? **[2]**

48. On the application of a constant torque, a wheel is turned from rest through 400 radians in 10 s. **[2]**

    i. Find angular acceleration,

    ii. If same torque continues to act, what will be the angular velocity of the wheel after 20s from start?

49. Why force is applied at right angles to the heavy door at the outer edge while closing or opening it? **[2]**

Section C

50. **Fill in the blanks:** **[3]**

    (a) Torque due to a force is due to its _____ component and not due to its _____ component. **[1]**

    (b) The angular momentum of a body of mass m moving in a circular path of radius r with constant speed v is _____. **[1]**

    (c) Rate of change of angular momentum is equal to the _____ applied. **[1]**

51. Establish a relation between torque and angular momentum for a system of particles. **[3]**

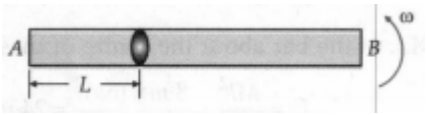
52. How torque is expressed as the vector product of two vectors? State the rule for determining the direction of torque. **[3]**

53. Define angular momentum. Derive the relation between angular momentum and torque. **[3]**

54. A solid cylinder of radius 4 cm and mass 250 g rolls down an inclined plane (1 in 10). Calculate the acceleration and the total energy of the cylinder after 5s. **[3]**

55. A long horizontal rod has a bead which can slide along its length and is initially placed at I a distance L from one end A of the rod. The rod is set in angular motion about A with a constant angular acceleration α. If the **[3]**

coefficient of friction between the rod and the bead is μ, and gravity is neglected then, find the time after which the bead starts slipping.



56. Two particles, each of mass m and speed v, travel in opposite directions along parallel lines separated by a distance d. Show that the vector angular momentum of the two particle system is the same whatever be the point about which the angular momentum is taken. **[3]**

57. Show that moment of a couple does not depend on the point about which you take the moments. **[3]**

58. An electron of mass 9×10^{-31} kg revolves in a circle of radius $0.53\mathring{A}$ around the nucleus of hydrogen with a velocity of $2.2 \times 10^{6} ms^{-1}$. Show that its angular momentum is equal to $\frac{h}{2\pi}$, where h is Planck's constant of value 6.6×10^{-34} Js. **[3]**

59. How angular momentum can be expressed as the vector product of two vectors? How is its direction determined? **[3]**

60. A particle of mass m is projected from origin O with speed u at an angle θ with the positive x-axis. Find the angular momentum of particle at any time t about O before the particle strikes the ground again. **[3]**

61. Calculate the angular momentum of the earth rotating about its own axis. Mass of the earth = 5.98×10^{27} kg, mean radius of the earth = 6.37×10^{6} m M.I. of the earth $= \frac{2}{5}MR^2$. **[3]**

62. A uniform circular disc of radius R is rolling on a horizontal surface. Determine the tangential velocity **[3]**

    i. at the upper most point,

    ii. at the centre of mass and

    iii. at the point of contact.

63. A wheel of mass 5 kg and radius 0.40 m is rolling on a road without sliding with angular velocity 10 rad s^{-1}. The moment of inertia of the wheel about the axis of rotation is 0.65 kgm^2. What is the percentage of kinetic energy of rotation in the total kinetic energy of the wheel? **[3]**

64. What is torque? Give its unit. Show that it is equal to the product of force and the perpendicular distance of its line of action from the axis of rotation. **[3]**

65. A solid cylinder rolls down an inclined plane. Its mass is 2 kg and radius 0.1m If the height of the inclined plane is 4 m, what is its rotational K.E. when it reaches the foot of the plane? **[3]**

Section D

66. **State True or False:** **[4]**

    (a) Any force acting on the object will produce a torque. **[1]**

    (b) A planet revolves around the sun under the effect of its gravitational force. The torque acting on the planet due to the gravitational force is zero. **[1]**

    (c) To unscrew a nut fitted tightly to a bolt, we need a wrench with a long arm. **[1]**

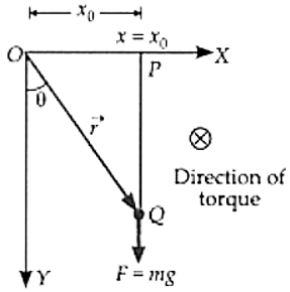
    (d) Angular momentum of a body in translatory motion is always zero. **[1]**

Section E

67. What is torque? Explain that torque is only due to the tangential component of force, radial component of force has nothing to do with the torque. **[5]**

68. Find the components along the x, y, z axes of the angular momentum l of a particle, whose position vector is r with components x, y, z and momentum is p with components p_x, p_y and p_z. Show that if the particle moves only in the x-y plane the angular momentum has only a z-component. **[5]**

69. A particle of mass m is released from point P at x = x_0 on the X-axis from origin O and falls vertically along the Y-axis, as shown in Fig. **[5]**



i. Find the torque t acting on the particle at a time t when it is at point Q with respect to O.

ii. Find the angular momentum L of the particle about O at this time t.

iii. Show that $\tau = \frac{dL}{dt}$ in this example.

70. State the law of conservation of angular momentum and illustrate it with the example of planetary motion. **[5]**