Systems of Particles and Rotational Motion

Assertion Reason Questions

Two statements are given one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes

(a), (b), (c) and (d) as given below:
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true and R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false and R is also false.

1. Assertion (A): The length of the day would increase if the earth shrink.
Reason (R): It would take longer for smaller items to complete one rotation around their axis.

Ans. (d) A is false and R is also false.
Explanation: If the earth were to shrink, the length of the day would decrease. This is in according to the principle of conservation of angular momentum;
i.e.. lo = constant

$$i.e., \quad (MK^2)\left(\frac{2\pi}{T}\right) = \text{constant}$$
$$T \propto K^2$$

2. Assertion (A): Torque is due to the transverse component of force only. The radical component has no role to play.
Reason (R): This is because the transverse component is not perpendicular to the radial component.

Ans. (c) A is true but R is false.
Explanation: As we know that,

$$\tau = \vec{r} \times \vec{F}$$
$$\tau = rF\sin\phi \qquad \text{...(i)}$$

The figure given below shows the relative orientation of r and F.

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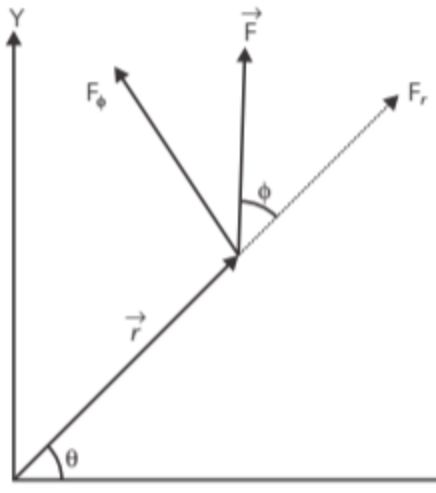

Resolve $\vec{F}$ into two rectangular components:

(1) $F_r = F \cos \phi$

$= \text{radial component of } \vec{F}$

(2) $F_\phi = F \sin \phi$

$= \text{transverse component of } \vec{F}$

From eq (i),

$\tau = r(F\sin\phi)$

$= rF_\phi$

i.e., Torque of a force is given by the product of the transverse component of a force and perpendicular distance from the axis of rotation. The radial component has no role play in torque.

3. Assertion (A): The condition of equilibrium for a rigid body is:
Translational motion-> F = 0,
(i.e., the sum of all external forces equal to zero).
Rotational motion-Σt = 0,
(i.e., the sum of all external torque equal to zero).
Reason(R): Under the operation of two equal and opposite forces, a rigid body must be in balance.

Ans. (c) A is true but R is false.
Explanation: Under the operation of two equal and opposite forces, a rigid body must be in balance.
Condition for mechanical equilibrium;
(1) The total force i.e., the vector sum of the forces on the rigid body is zero.
(2) The total torque i.e., the vector sum of the torques on the rigid body is zero.

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$$\vec{F}_1+\vec{F}_2+\ldots\ldots\vec{F}_n=0$$

$$\vec{\tau}_1+\vec{\tau}_2+\ldots\ldots\vec{\tau}_n=0$$

If the forces on the rigid body are acting in the 3 dimensions, then six independent conditions are to be satisfied for the mechanical equilibrium of a rigid body. If all the forces acting on the body are co- planar, then we need only three conditions to be satisfied for mechanical equilibrium. A body may be in partial equilibrium i.e., it may be in translational equilibrium and not in rotational equilibrium and not in translational equilibrium.

4. Assertion (A): A pipe wrench with a longer arm is required to unscrew a rusty nut.
Reason (R): The force imparted to the arm is reduced by using a wrench with a longer arm.

Ans. (c) A is true but R is false.
Explanation: Torque is the quantity of force that can bring about an entity to rotate about the axis. Force is what makes an entity speed up in extended kinematics. Likewise, the torque is what generates angular acceleration. That is, torque can be explained as the rotational comparable of linear force. The torque or moment of force is the product of force and perpendicular distance from the pivot. Therefore, the longer the arm it will give more torque for small applying force and more torque will help to open the screw easily.

5. Assertion (A): Many great rivers flow towards the equator. The small particle that they carry increases the time of rotation of the earth about its axis.
Reason (R): The angular momentum of the earth about its rotation axis is conserved

Ans. (a) Both A and R are true and R is the correct explanation of A.
Explanation: In the absence of external torque, the angular momentum of the system is conserved.

$L = I\omega = \text{constant}$

Due to the flow of the river towards the equator, the sediments also move towards the equator which as a result increases the Moment of inertia (1) of the earth, thus decreasing angular velocity of the earth so that angular momentum remains constant.

As $\omega=\frac{2\pi}{t}$

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6. Assertion (A): The center of mass of a body may lie where there is no
Reason (R): mass. The center of mass has nothing to do with the mass of the body.

Ans: (a) Both A and R are true and R is the correct explanation of A.
Explanation: Like Center of mass of the ring lies at its geometric center where even thereis no mass of any part of the ring. So, both the Assertion and reason statements are correct and reason explains the assertion very well.

7. Assertion (A): A wheel moving down a perfectly frictionless inclined plane will undergo slipping.
Reason (R): For pure rolling, the work done against frictional force is zero.

Ans. (b) Both A and R are true and R is not the correct explanation of A.
Explanation: Rolling occurs only on account of friction which is a tangential force capable of providing torque when the inclined plane is perfectly smooth, it will simply slip under the effect of its weight. Once the perfect rolling begins, the force of friction becomes zero. Hence, the work done against friction is zero.

8. Assertion (A): The speed of a whirlwind in the tornado is alarmingly high.
Reason (R): If no external torque acts on a body, its angular velocity remains constant.

Ans. (c) A is true but R is false.
Explanation: In a whirlwind in a tornado, the air from nearby regions gets concentrated in a small space thereby decreasing the value of its moment of inertia considerably. Since, lw constant, so due to the decrease in the moment of inertia of the air, its angular speed increases to a high value. If no external torque acts, then

$$\tau = 0 \text{ or } \frac{dL}{dt} = 0 \text{ or } L = \text{constant}$$

or $$= I\omega = \text{constant}$$

As in the rotational motion, the moment of inertia of the body can change due to the change in position of the axis of rotation, the angular speed may not remain conserved.

9. Assertion (A): Moment of inertia is always constant.
Reason (R): Angular moment is conserved, that is why the moment of inertia is constant.

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Ans. (a) Both A and R are true and R is the correct explanation of A.
Explanation: The moment of inertia is not a fixed quantity, but depends on the orientation and position of the axis of rotation with respect to the body as a whole.

10. Assertion (A): The spokes near the top of a rolling bicycle wheel are more blurred than those near the bottom of the wheel.
Reason (R): The spokes near the top of the wheel are moving faster than those near the bottom of the wheel.

Ans. (a) Both A and R are true and R is the correct explanation of A.
Explanation: The spokes near the top of the wheel are more blurred than those near the bottom of the wheel because they are moving faster. The wheel pushes on the ground at a certain speed to move the bike in an opposite direction but with an equal speed. The bike and thus the bottom of the wheel translates at a speed equal to but in an opposite direction to the rotational velocity of the bottom of the wheel. The pure rotation and the pure translation cancel each other, yielding a net velocity of zero at the bottom of the wheel. Because the very bottom of the wheel has a zero net velocity, the camera captures it sharply.

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