Chapter 4

1. What are rectangular components of a vector and their values?

Ans: Horizontal (x) component: The part of the vector along the x-axis, $F_x = F \cos \theta$.

   Vertical (y) component: The part of the vector along the y-axis, $F_y = F \sin \theta$.

2. What is the line of action of a force?

Ans: The **line of action of a force** is the **line along which the force acts**. For example, in a figure, **BC** represents the line of action of force **F**.

3. Define moment of a force. Prove that τ=rFsin⬜θ\tau = rF \sin \thetaτ=rFsinθ, where θ is the angle between r and F.
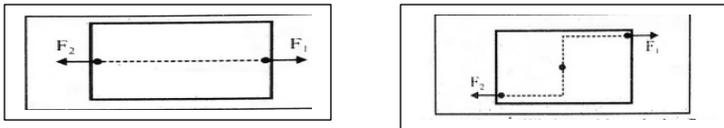
Ans: The **moment of a force** (torque) is the **product of the force and the perpendicular distance** from the axis of rotation (moment arm):

$$\tau = r \times l$$
$$L\sin\theta = r \qquad \tau = rL\sin\theta$$

4. With the help of a diagram, show that the resultant force is zero but the resultant torque is not zero.

Ans: Two **equal and opposite forces** act on a body **along different lines** (not the same line of action).

   Their **resultant force is zero** because they cancel each other.

   Their **resultant torque is not zero** because the forces produce a **tendency to rotate**, so the body is not in equilibrium despite zero net force.

This shows that **zero net force does not always mean zero torque**.

5. Identify the state of equilibrium in each case in the figure given below.

Ans:
(a) **Stable equilibrium**
(b) **Unstable equilibrium**
(c) **Neutral equilibrium**
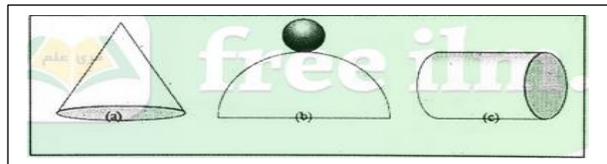
6. Give an example of a body which is moving yet in equilibrium.

Ans: A **paratrooper descending at terminal velocity** is in equilibrium because the **acceleration is zero**.

7. **What are two basic principles of stability in physics applied in designing balancing toys and racing cars?**

Ans:

1. The **centre of gravity should be low** to increase stability.
2. When disturbed, the **body should return to its original position** as the centre of gravity lowers, restoring stability.

8. **How can you prove that the centripetal force always acts perpendicular to velocity?**

Ans: The **velocity** of a body in circular motion is **tangent** to the path, while the **centripetal force** points **radially inward**.
Since they are at **90° to each other** (dot product = 0), the **centripetal force is always perpendicular to velocity**.

CRQ

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1. **A car travels at the same speed around two curves with different radii. For which radius does the car experience more centripetal force? Prove your answer.**

Ans: The car experiences **more centripetal force** on the curve with the **smaller radius**.
Reason: Centripetal force is $F_c = mv^2/r$. As **radius (r) decreases**, F_c **increases**, so the smaller radius requires a larger force.

2. **A ripe mango does not normally fall from the tree. But when the branch of the tree is shaken, the mango falls down easily. Can you tell the reason?**

Ans: The mango stays attached by its stem, but **shaking the branch applies an external force** that weakens the attachment, allowing **gravity to pull the mango down**.

3. **Discuss the concepts of stability and centre of gravity in relation to objects toppling over. Provide an example where an object's centre of gravity affects its stability, and explain how altering its base of support can influence stability.**

Ans: Stability is an object's ability to **resist changes** in position. An object is **stable** if its **centre of gravity (CoG) lies inside its base of support**, and **unstable** if it tends to topple when disturbed.

Example: A person standing upright has a **high CoG** and is less stable; crouching lowers the CoG, increasing stability. Increasing the **base of support** (e.g., spreading feet) also **enhances stability**, while a tall object with a **narrow base** is more likely to topple.

4. **Why can an accelerated body not be considered in equilibrium?**

Ans: An accelerated body **cannot be in equilibrium** because a **net force produces acceleration**, so the body does not remain at rest or in uniform motion.

Two boxes of the same weight but different heights are lying on the floor of a truck. If the truck makes a sudden stop, which box is more likely to tumble over? Why?

Ans: The **taller box** is more likely to tumble because its **higher centre of gravity** makes it less stable. During the sudden stop, its **inertia tilts it**, moving the centre of gravity outside the base and causing it to fall.