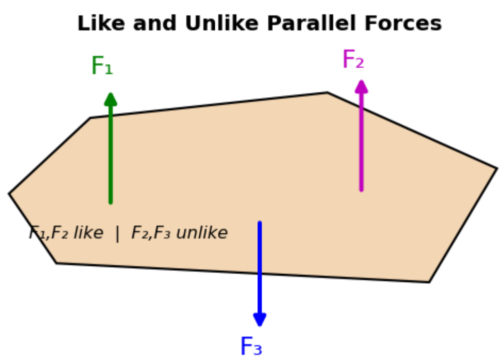
# Short Answer Questions

## Chapter 4: Turning Effects of Force

*9th Class Physics — New Syllabus (PCTB)*

### 4.1 Define like and unlike parallel forces.

Forces that act parallel to one another are called parallel forces, and their points of application may be different. If parallel forces act in the same direction, they are called **like parallel forces**. If they act in opposite directions, they are called **unlike parallel forces**. For example, in a body acted on by three parallel forces $F_1$, $F_2$ and $F_3$, if $F_1$ and $F_2$ point the same way they are like parallel forces, while $F_2$ and $F_3$ pointing opposite ways are unlike parallel forces.




### 4.2 What are rectangular components of a vector and their values?

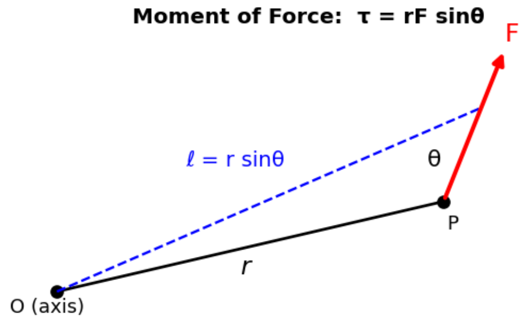
When a vector is resolved into two components perpendicular (at 90°) to each other, these are called its rectangular components — the x-component and the y-component. For a force F making angle θ with the x-axis, the horizontal component is $\mathbf{F_x = F\cos\theta}$ and the vertical component is $\mathbf{F_y = F\sin\theta}$. Their resultant is equal to the original vector, and since they are perpendicular, the magnitude is $F = \sqrt{(F_x^2 + F_y^2)}$.

### 4.3 What is the line of action of a force?

The line along which a force acts is called the line of action of the force. In other words, it is the straight line drawn through the point of application of the force in the direction in which the force is acting. This concept is important in finding the moment arm, because the moment arm is the perpendicular distance of this line of action from the axis of rotation. If the line of action passes through the axis of rotation, the moment arm becomes zero and the torque is also zero.

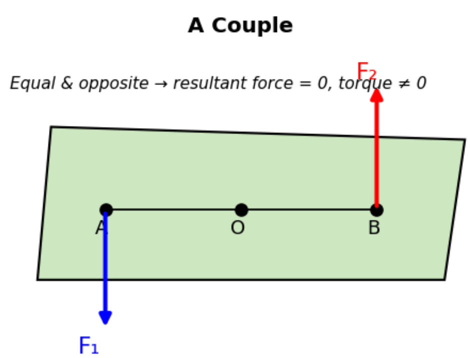
### 4.4 Define moment of a force. Prove that τ = rF sinθ, where θ is the angle between r and F.

The turning effect of a force is called moment of force or torque. It is defined as the product of the force and the moment arm: $\boldsymbol{\tau = F \times \ell}$. When the line joining the axis O and the point of application P is not perpendicular to F, let r = OP make angle θ with F. The moment arm is the perpendicular component $\boldsymbol{\ell = r\sin\theta}$. Putting this in $\tau = F \times \ell$ gives $\boldsymbol{\tau = rF\sin\theta}$. Its SI unit is newton-metre (N m).



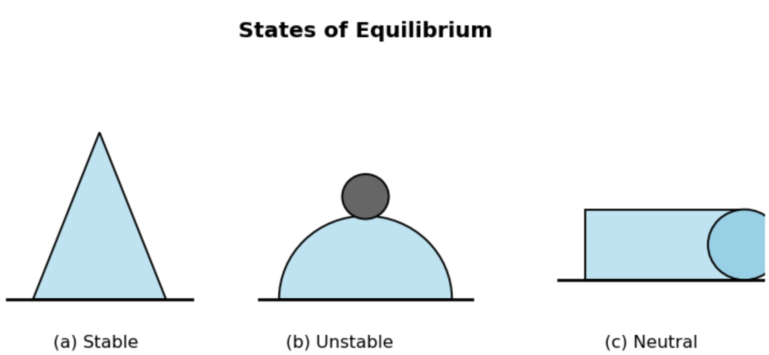

### 4.5 With the help of a diagram, show that the resultant force is zero but the resultant torque is not zero.

When two equal and opposite parallel forces act at two different points of the same body, they form a **couple**. Because the two forces are equal in magnitude and opposite in direction, their vector sum (resultant force) is zero, so the first condition of equilibrium is satisfied. However, since they act along different lines of action, they produce turning effects in the same rotational sense, so the resultant torque is not zero and the body rotates. Example: turning a steering wheel or a water tap.




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

(a) The cone resting on its **base** is in **stable equilibrium**, because after a slight tilt its centre of gravity rises and it returns to its original position. (b) The ball resting on top of the **dome (convex surface)** is in **unstable equilibrium**, because on the slightest disturbance its centre of gravity falls and it rolls away, not returning. (c) The **cylinder** lying on its side is in **neutral equilibrium**, because when rolled the height of its centre of gravity stays the same, so it stays in the new position.




### 4.7 Give an example of a body which is moving yet in equilibrium.

A paratrooper descending with an open parachute at constant (uniform) velocity is moving yet in equilibrium. After the parachute opens, the downward force of gravity is exactly balanced by the upward air resistance, so the net force is zero and there is no acceleration. A body moving with uniform velocity under zero net force is said to be in **dynamic equilibrium**. Other examples: a car moving at constant velocity on a straight road, or a jet cruising at steady speed.

### 4.8 Define centre of mass and centre of gravity of a body.

The **centre of mass** of a body is that point where the whole mass of the body is assumed to be concentrated, and the body behaves as if all its mass lies at that point. The **centre of gravity** is that point where the total weight of the body appears to act. If a body is supported at its centre of gravity, it stays balanced without rotating. On the surface of the Earth, where g is almost uniform, the centre of mass and centre of gravity of a body coincide.

### 4.9 What are two basic principles of stability in physics which are applied in designing balancing toys and racing cars?

The stability of an object is improved by two basic principles: (i) **lowering the centre of gravity**, and (ii) **increasing (widening) the area of the base**. In racing cars, the centre of mass is kept as low as possible and the base area is increased by keeping the wheels outside the main body, so the car does not topple at sharp turns. In balancing toys, the centre of gravity is kept below the pivot point, so the toy always returns to its stable position after being disturbed.

### 4.10 How can you prove that the centripetal force always acts perpendicular to velocity?

When a body moves along a circular path with uniform speed, its velocity at any point is directed along the **tangent** to the circle at that point. If the centripetal force F were not perpendicular to velocity v, it would have a component along v equal to F cos θ. This component would change the magnitude of the velocity (the speed). But the speed is constant, which is possible only if this component is zero, i.e. **F cos 90° = 0**. Hence the centripetal force must act at 90° to velocity, directed towards the centre.

F ⊥ v in Circular Motion