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Class	9th	Chapter	04
Subject	Physics	Board	Punjab

CHAPTER 04: TURNING EFFECTS OF FORCES — COMPLETE SOLUTIONS

A. Multiple Choice Questions

- **4.1. A particle is simultaneously acted upon by two forces of 4 and 3 newtons. The net force on the particle is:**
  - **Options:** (a) 1 N | (b) **between 1 N and 7 N** *(Correct Answer)* | (c) 5 N | (d) 7 N
  - *Explanation:* The magnitude of the resultant of two forces ranges from the difference of their magnitudes ($|4 - 3| = 1$ N) to the sum of their magnitudes ($4 + 3 = 7$ N), depending on the angle between them.
- **4.2. A force F is making an angle of 60° with x-axis. Its y-component is equal to:**
  - **Options:** (a) F | (b) $F \sin 60°$ *(Correct Answer)* | (c) $F \cos 60°$ | (d) $F \tan 60°$
  - *Explanation:* The y-component of a vector making angle θ with the x-axis is given by $F_y = F \sin \theta$.
- **4.3. Moment of force is called:**
  - **Options:** (a) moment arm | (b) couple | (c) couple arm | (d) **torque** *(Correct Answer)*
  - *Explanation:* The turning effect of a force is called torque or moment of force.
- **4.4. If F_1 and F_2 are the forces acting on a body and τ is the torque produced in it, the body will be completely in equilibrium, when:**
  - **Options:** (a) $\sum F = 0$ **and** $\sum \tau = 0$ *(Correct Answer)* | (b) $\sum F = 0$ and $\sum \tau \neq 0$ | (c) $\sum F \neq 0$ and $\sum \tau = 0$ | (d) $\sum F \neq 0$ and $\sum \tau \neq 0$
  - *Explanation:* Complete equilibrium (both translational and rotational) requires both net force and net torque to be zero.
- **4.5. A Shopkeeper sells his articles by a balance having unequal arms of the pans. If he puts the weights in the pan having shorter arm, then the customer:**

- **Options:** (a) **loses** *(Correct Answer)* | (b) gains | (c) neither loses nor gains | (d) not certain
- *Explanation:* By the principle of moments ($W_1L_1 = W_2L_2$), if the pan has a shorter arm, a heavier weight is required on the item side to balance a smaller standard weight, meaning the customer gets less goods for the price (loses).

- **4.6. A man walks on a tight rope. He balances himself by holding a bamboo stick horizontally. It is an application of:**
  - **Options:** (a) law of conservation of momentum | (b) Newton's second law of motion | (c) **principle of moments** *(Correct Answer)* | (d) Newton's third law of motion
  - *Explanation:* Holding a long bamboo stick lowers his overall center of gravity and allows him to adjust torques by shifting the stick to maintain rotational equilibrium.
- **4.7. In stable equilibrium, the centre of gravity of the body lies:**
  - **Options:** (a) at the highest position | (b) **at the lowest position** *(Correct Answer)* | (c) at any position | (d) outside the body
  - *Explanation:* When displaced, the center of gravity of a body in stable equilibrium rises to a higher position, meaning it naturally rests at the lowest possible position.
- **4.8. The centre of mass of a body:**
  - **Options:** (a) lies always inside the body | (b) lies always outside the body | (c) lies always on the surface of the body | (d) **may lie within, outside or on the surface** *(Correct Answer)*
  - *Explanation:* For regular solid objects, it lies inside; for hollow or ring-shaped objects, it can lie outside the physical material (e.g., center of mass of a ring is at its geometric center).
- **4.9. A cylinder resting on its circular base is in:**
  - **Options:** (a) **stable equilibrium** *(Correct Answer)* | (b) unstable equilibrium | (c) neutral equilibrium | (d) none of these
  - *Explanation:* If tilted slightly, its center of gravity rises and it returns to its original base position.
- **4.10. Centripetal force is given by:**
  - **Options:** (a) rF | (b) $rF\cos\theta$ | (c) $\frac{mv^2}{r}$ *(Correct Answer)* | (d) $\frac{mv}{r^2}$
  - *Explanation:* The formula for centripetal force in circular motion is $F_c = \frac{mv^2}{r}$.

B. Short Answer Questions

- **4.1. Define like and unlike parallel forces.**
  - **Answer:**
    - *Like parallel forces:* Forces that lie along the same or parallel lines and act in the same direction.
    - *Unlike parallel forces:* Forces that lie along parallel lines but act in opposite directions.
- **4.2. What are rectangular components of a vector and their values?**
  - **Answer:** Rectangular components are two mutually perpendicular components of a vector along the x and y axes. For vector $\vec{F}$ making angle θ with the x-axis: $F_x = F\cos\theta$ and $F_y = F\sin\theta$.
- **4.3. What is the line of action of a force?**
  - **Answer:** The line of action of a force is the infinite straight line along which the force vector acts.
- **4.4. Define moment of a force. Prove that $\tau = rF\sin\theta$, where θ is angle between r and F.**
  - **Answer:** Moment of force (torque) is the turning effect of a force about a pivot point.
    - *Proof:* Torque τ = Force × perpendicular distance from pivot = $F \times (r\sin\theta) = rF\sin\theta$.
- **4.5. With the help of a diagram, show that the resultant force is zero but the resultant torque is not zero.**
  - **Answer:** This represents a **couple**. Two equal and opposite parallel forces acting at different points produce zero net force ($\sum F = 0$) but produce a non-zero net torque ($\sum \tau \neq 0$), such as when turning a water tap or steering wheel.
- **4.6. Identify the state of equilibrium in each case in the figure given below.**
  - **Answer:**
    - (a) Cone on its base: **Stable equilibrium**.
    - (b) Sphere on a curved surface/bowl: **Neutral or stable** (depending on placement).
    - (c) Cylinder resting on its curved side: **Neutral equilibrium**.
- **4.7. Give an example of the body which is moving yet in equilibrium.**
  - **Answer:** A parachutist falling vertically downward at a constant terminal velocity (net force = 0, acceleration = 0) or a car moving at a constant speed along a straight highway.
- **4.8. Define centre of mass and centre of gravity of a body.**
  - **Answer:**

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- *Centre of mass:* The point where the entire mass of a body appears to be concentrated for translational motion.
- *Centre of gravity:* The point where the entire weight of the body appears to act, resulting in zero net gravitational torque.

- **4.9. What are two basic principles of stability in physics which are applied in designing balancing toys and racing cars?**
  - **Answer:**
    1. Lowering the centre of gravity as much as possible.
    2. Increasing the base area of support.
- **4.10. How can you prove that the centripetal force always acts perpendicular to velocity?**
  - **Answer:** In uniform circular motion, the velocity vector is always tangential to the circular path at any given point, while the centripetal force always points directly towards the center of the circle (along the radius vector, which is perpendicular to the tangent). Hence force and velocity are perpendicular.

C. Constructed Response Questions

- **4.1. A car travels at the same speed around two curves with different radii. For which radius the car experiences more centripetal force? Prove your answer.**
  - **Answer:** Centripetal force $F_c = \frac{mv^2}{r}$. Since mass m and speed v are constant, F_c is inversely proportional to radius r ($F_c \propto \frac{1}{r}$). Therefore, the car experiences more centripetal force on the curve with the **smaller radius**.
- **4.2. 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?**
  - **Answer:** When the branch is shaken, it moves suddenly, but the mango tends to remain at rest due to its inertia. This sudden relative motion strains and snaps the stem, causing the ripe mango to detach and fall under gravity.
- **4.3. Discuss the concepts of stability and centre of gravity in relation to objects toppling over...**
  - **Answer:** An object topples when the vertical line drawn from its center of gravity falls outside its base of support. *Example:* A racing car is built low with wide wheels (low CG, wide base) to prevent toppling during sharp turns. Widening the base of support and lowering the CG increases stability.
- **4.4. Why an accelerated body cannot be considered in equilibrium?**
  - **Answer:** By definition, a body in equilibrium must have zero acceleration (constant velocity and zero net force for translational equilibrium; zero angular acceleration for rotational equilibrium). Acceleration implies a net unbalanced force or torque is acting.

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- **4.5. 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?**
    - **Answer:** The **taller box** is more likely to tumble over. Its center of gravity is higher up, creating a larger torque when the truck stops abruptly, making the line of action of weight exit its base more easily compared to the shorter box.

D. Comprehensive Questions

- **4.1. Explain the principle of moments with an example.**
    - **Answer:** The principle of moments states that a body is in rotational equilibrium when the sum of clockwise moments about a pivot equals the sum of anticlockwise moments about the same pivot ($\sum \tau = 0$). *Example:* A balanced see-saw where $W_1 L_1 = W_2 L_2$.
- **4.2. Describe how could you determine the centre of gravity of an irregular shaped lamina experimentally.**
    - **Answer:** By the plumb-line method: Suspend the irregular lamina freely from a pin hole at one corner along with a plumb line. Draw a vertical line along the plumb string. Repeat this by suspending the lamina from two other separate corners. The intersection point of these three lines gives the center of gravity.
- **4.3. State and explain two conditions of equilibrium.**
    - **Answer:**
        1. *First Condition of Equilibrium:* The vector sum of all forces acting on the body must be zero ($\sum F = 0$), ensuring translational equilibrium.
        2. *Second Condition of Equilibrium:* The sum of all torques acting on the body must be zero ($\sum \tau = 0$), ensuring rotational equilibrium.
- **4.4. How the stability of an object can be improved? Give a few examples to support your answer.**
    - **Answer:** Stability can be improved by: (1) Lowering the center of gravity, (2) Increasing the base area of support. *Examples:* Circus tightrope walkers holding a heavy pole downwards, double-decker buses having heavy engines at the bottom.

E. Numerical Problems

- **4.1. A force of 200 N is acting on a cart at an angle of 30° with the horizontal direction. Find the x and y-components of the force.**
    - **Answer:**
        - $F = 200$ N, $\theta = 30°$
        - $F_x = F\cos(30°) = 200 \times 0.866 = \mathbf{173.2}$ N.
        - $F_y = F\sin(30°) = 200 \times 0.5 = \mathbf{100}$ N.
- **4.2. A force of 300 N is applied perpendicularly at the knob of a door to open it as shown in the given figure. If the knob is 1.2 m away from the hinge, what is the torque applied? Is it positive or negative torque?**

- **Answer:**
  - $F = 300$ N, $r = 1.2$ m, $\theta = 90°$
  - Torque $\tau = rF\sin\theta = 1.2 \times 300 \times \sin(90°) = \mathbf{360}$ N · m (positive, counter-clockwise).

- **4.3. Two weights are hanging from a metre rule at the positions as shown in the given figure. If the metre rule is balanced at its centre of gravity (C.G), find the unknown weight w.**
  - **Answer:**
    - Left side weight = w at distance 40 cm. Right side weight = 4 N at distance 30 cm.
    - By principle of moments: $w \times 40 = 4 \times 30 \Longrightarrow 40w = 120 \Longrightarrow w = \frac{120}{40} = \mathbf{3}$ N.
- **4.4. A see-saw is balanced with two children sitting near either end. Child A weighs 30 kg and sits 2 metres away from the pivot, while child B weighs 40 kg and sits 1.5 metres from the pivot. Calculate the total moment on each side and determine if the sea-saw is in equilibrium.**
  - **Answer:**
    - Moment A $= 30$ kg $\times 9.8 \times 2$ m $= 588$ N · m (or $30 \times 2 = 60$ kg · m).
    - Moment B $= 40$ kg $\times 9.8 \times 1.5$ m $= 588$ N · m (or $40 \times 1.5 = 60$ kg · m).
    - Since both sides have equal and opposite moments, the see-saw is in **equilibrium**.
- **4.5. A crowbar is used to lift a box as shown in the given figure. If the downward force of 250 N is applied at the end of the bar, how much weight does the other end bear? The crowbar itself has negligible weight.**
  - **Answer:**
    - Load distance = 5 cm, effort arm = 30 cm + 5 cm = 35 cm.
    - By torque balance: Load $\times 5 = 250 \times 30 \Longrightarrow$ Load $= \frac{7500}{5} = \mathbf{1500}$ N.
- **4.6. A 30 cm long spanner is used to open the nut of a car. If the torque required for it is 150 N m, how much force F should be applied on the spanner as shown in the figure given below.**
  - **Answer:**
    - $\tau = 150$ N · m, $r = 30$ cm $= 0.3$ m.
    - $\tau = F \times r \Longrightarrow 150 = F \times 0.3 \Longrightarrow F = \frac{150}{0.3} = \mathbf{500}$ N.
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- **4.7. A 5 N ball hanging from a rope is pulled to the right by a horizontal force F. The rope makes an angle of 60° with the ceiling, as shown in the given figure. Determine the magnitude of force F and tension T in the string.**
  - **Answer:**
    - Weight $W = 5$ N downward. Angle with ceiling = 60°, so angle with vertical = 30°.
    - Vertical equilibrium: $T\cos(30°) = 5 \Rightarrow T \times 0.866 = 5 \Rightarrow T = \frac{5}{0.866} \approx \mathbf{5.8}$ N.
    - Horizontal equilibrium: $F = T\sin(30°) = 5.8 \times 0.5 = \mathbf{2.9}$ N.
- **4.8. A signboard is suspended by means of two steel wires as shown in the given figure. If the weight of the board is 200 N, what is the tension in the strings?**
  - **Answer:**
    - Weight $W = 200$ N symmetrically suspended.
    - By symmetry: $T_1 + T_2 = 200$ N $\Rightarrow T_1 = T_2 = \frac{200}{2} = \mathbf{100}$ N each.
- **4.9. One girl of 30 kg mass sits 1.6 m from the axis of a see-saw. Another girl of 40 kg wants to sit on the other side, so that the see-saw may remain in equilibrium. How far away from the axis, the other girl may sit?**
  - **Answer:**
    - $m_1 = 30$ kg, $r_1 = 1.6$ m. $m_2 = 40$ kg, $r_2 =$?
    - $m_1 r_1 = m_2 r_2 \Rightarrow 30 \times 1.6 = 40 \times r_2 \Rightarrow 48 = 40 r_2 \Rightarrow r_2 = \frac{48}{40} = \mathbf{1.2}$ m.
- **4.10. Find the tension in each string as shown in the given figure, if the block weighs 150 N.**
  - **Answer:**
    - Vertical component $T_1\cos(30°) = 150$ N $\Rightarrow T_1 \times 0.866 = 150 \Rightarrow T_1 = \frac{150}{0.866} \approx \mathbf{173.2}$ N.
    - Horizontal component $T_2 = T_1\sin(30°) = 173.2 \times 0.5 = \mathbf{86.6}$ N.

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