ICSE CLASS 10 · PHYSICS

Chapter 1 : FORCE

STEP-BY-STEP SOLUTIONS & MARKING SCHEME (40 MARKS)

Maximum Marks: 40 · Section A (20) compulsory · Section B: any two of three questions (2 × 10 = 20)

Marks for each step are shown in square brackets on the right. Sign convention used: anticlockwise moment = positive, clockwise moment = negative.

SECTION A (20 Marks)

Question 1 — Multiple choice [8 marks, 1 mark each]

No.	Answer	Reason
(i)	**(c)** N m	Moment = force × distance, so unit = N × m = N m.
(ii)	**(b)** 5 N m	Moment = F × r = 20 × 0.25 = 5 N m.
(iii)	**(b)** 2 N m	Moment of couple = F × d = 5 N × 0.4 m = 2 N m.
(iv)	**(d)** a raindrop falling with constant velocity	A raindrop moving with constant velocity has balanced forces (weight = buoyancy + friction): dynamic equilibrium. The others are at rest or have a net force.
(v)	**(a)** (A) is true and (R) is false.	(A) is true: the longer handle increases the perpendicular distance, so the moment is larger. (R) is false: the force applied is the same; it is the *moment* that increases.
(vi)	**(b)** 70 cm mark	Anticlockwise moment of 40 gf = 40 × (50 − 10) = 1600 gf cm. For 80 gf at distance d on the other side: 80 × d = 1600, so d = 20 cm, i.e. at the 50 + 20 = 70 cm mark.
(vii)	**(d)** at its centre, where there is no material	The C.G. of a ring lies at its geometric centre, where there is no material.
(viii)	**(a)** directed towards the centre of the circle	In uniform circular motion the acceleration (centripetal) is always directed towards the centre.

Question 2 [6 marks]

(a) The **moment of a force** about an axis is the product of the magnitude of the force and the perpendicular distance of the line of action of the force from the axis of rotation. [1] **[2]**

S.I. unit: **newton metre (N m)**. It is a **vector** quantity. [½ + ½]

(b) Fig. 1(a): the force acts at A, below O, to the right → the disc rotates **anticlockwise**. [½] **[2]**

Fig. 1(b): the same force acts at B, above O, to the right → the disc rotates **clockwise**. [½]

The **sense of rotation** depends on the point of application of the force (the side of the pivot on which it acts), even when the magnitude and direction of the force are unchanged. [1]

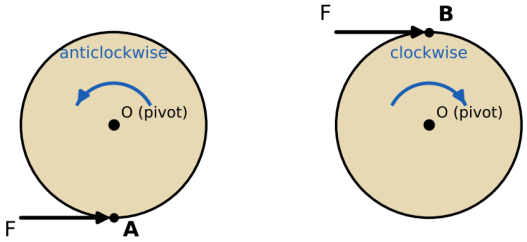


Fig. 1(a) *Fig. 1(b)*

Solution to Q2(b)

(c) (i) Centripetal force acts **towards the centre** of the circular path; centrifugal force acts **away from the centre**. [1] **[2]**

(ii) Centripetal force is a **real** force (tension, gravity, electrostatic force); centrifugal force is a **fictitious** (pseudo) force assumed by an observer moving with the body. [1]

Question 3 [6 marks]

(a) Given: F = 15 N, r = 20 cm = 0.2 m. **[3]**

Moment = F × r = 15 × 0.2 = **3 N m**. [1½]

For r′ = 30 cm = 0.3 m: F′ × 0.3 = 3 → F′ = 3 ÷ 0.3 = **10 N**. [1½]

(b) **Principle of moments:** for a body in equilibrium, the sum of the anticlockwise moments about any point = the sum of the clockwise moments about the same point. [1] **[3]**

Pivot is at 50 cm. The 60 gf weight is (50 − 20) = 30 cm from the pivot (anticlockwise): moment = 60 × 30 = 1800 gf cm. [1]

Let 40 gf be at distance d on the other side: 40 × d = 1800 → d = 45 cm. Mark = 50 + 45 = **95 cm**. [1]

SECTION B (20 Marks) — any two questions

Question 4 [10 marks]

(a) (i) A long handle increases the perpendicular distance of the force from the nut, so a **small force** gives a large moment. [1] **[3]**

(ii) With a large diameter, the tangential force acts at a greater distance from the axis, so the **moment is larger** and the wheel turns more easily. [1]

(iii) The handle near the rim is far from the central pivot, so a **small force** can rotate the heavy stone easily. [1]

(b) Given: breadth of door = 1.2 m, F = 25 N applied at the free end, so r = 1.2 m. **[3]**

Moment = F × r = 25 × 1.2 = **30 N m**. [1½]

Force F′ at r′ = 0.3 m: F′ × 0.3 = 30 → F′ = 30 ÷ 0.3 = **100 N**. [1½]

(c) Anticlockwise moments are positive and clockwise moments negative. **[4]**

(i) **F_1 = 12 N at A** (left of O, acting downwards): it turns the rod anticlockwise. OA = 0.5 m.

M_1 = +12 × 0.5 = **+6 N m (anticlockwise)** [1]

F_2 = 5 N at B (right of O, acting downwards): clockwise. OB = 2 − 0.5 = 1.5 m.

M_2 = −5 × 1.5 = **−7.5 N m (clockwise)** [1]

F_3 = 4 N at P (right of O, acting upwards): anticlockwise. OP = 1.5 ÷ 2 = 0.75 m.

M_3 = +4 × 0.75 = **+3 N m (anticlockwise)** [1]

(ii) Resultant moment = 6 − 7.5 + 3 = **+1.5 N m, i.e. 1.5 N m anticlockwise**. Since it is not zero, the rod is **not** in rotational equilibrium. [1]

Question 5 [10 marks]

(a) Couple arm = diameter = 2 × 0.2 = 0.4 m. **[3]**

(i) Moment of couple = F × d = 15 × 0.4 = **6 N m**. [1½]

(ii) 1 N m = 10^7 dyne cm, so 6 N m = **6×10^7 dyne cm**. [1]

The resultant force of the two equal and opposite forces is zero, so the disc has **no translational motion**; it only rotates. [½]

(b) Take the pivot at the middle (3 m from each end). Moment of the 36 kg child = 36 × 2 = 72 kgf m. **[3]**

(i) For balance: 24 × d = 72 → d = **3 m** from the pivot, i.e. at the **end** of the see-saw. [1½]

(ii) New distance = 3 − 0.5 = 2.5 m, so the moment of the 24 kg child = 24 × 2.5 = 60 kgf m. [½]

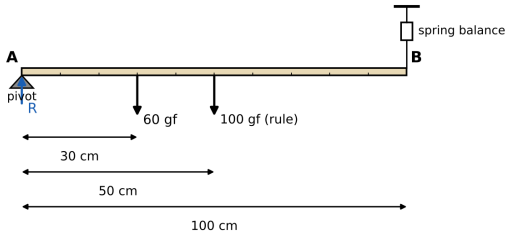
The 36 kg child's side (72 kgf m) is greater, so that side goes **down**. Resultant moment = 72 − 60 = **12 kgf m** (≈ 117.6 N m) in the direction of the 36 kg child's moment. [1]

(c) Let the reading of the spring balance be F gf (upward force at B). The rule's weight 100 gf acts at its mid-point (50 cm mark). Take moments about the pivot A (the reaction R at A has zero moment). [1 for forces / diagram] **[4]**

(i) Clockwise moment about A = 60 × 30 + 100 × 50 = 1800 + 5000 = 6800 gf cm. [1]

Anticlockwise moment about A = F × 100. In equilibrium: F × 100 = 6800 → F = **68 gf**. [1]

(ii) Total downward force = 60 + 100 = 160 gf. For vertical equilibrium: R + F = 160 → R = 160 − 68 = **92 gf (upwards)**. [1]



Forces on the rule (solution to Q5(c))

Question 6 [10 marks]

(a) The **centre of gravity** of a body is the point about which the algebraic sum of the moments of the weights of all its particles is zero; the whole weight of the body can be considered to act at this point. [1] **[3]**

Yes, it can lie outside the material of the body. Example: the C.G. of a **ring** (or hollow sphere) lies at its centre, where there is no material. [1]

The position of the C.G. depends on the **shape of the body / distribution of mass** in it (it changes if the body is deformed). [1]

(b) (i) **Person on the ground** sees the ball moving in a **circular path**: the tension T in the string provides the centripetal force needed for circular motion. [1½] **[3]**

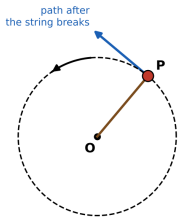
(ii) **Person on the platform** sees the ball **stationary**, just in front of him. He explains this by two forces: the tension T towards the centre and an equal and opposite **centrifugal force** away from the centre. The net force is zero, so the ball appears at rest. The centrifugal force is a **fictitious** force. [1½]

(c) (i) **Variable.** The speed is constant but the direction of motion changes at every point, so the velocity changes. [1] **[4]**

(ii) The acceleration at P is directed **towards the centre O along PO** (centripetal acceleration). [1]

(iii) The **tension in the string** provides the centripetal force. [1]

(iv) When the string breaks at P, the tension ceases to act and the stone moves in a **straight line along the tangent** at P (see figure). [1]



Solution to Q6(c)(iv)

Marks summary	
Section A: Q1 (8) + Q2 (3 × 2 = 6) + Q3 (2 × 3 = 6)	**20**
Section B: any two of Q4 – Q6 (10 marks each)	**20**
Total	**40**