MOMENT OF A FORCE

1 **(a)** Complete the following statement:

The moment of a force about a point is .....

multiplied by .....[1]

(b) Fig. 3.1 shows a uniform iron bar B of weight 30 N and length 1.40 m. The bar is being used to lift one edge of a concrete slab S. A stone, placed 0.20 m from one end of B, acts as a pivot. A force of 40 N pushing down at the other end of B is just enough to lift the slab and hold it as shown.

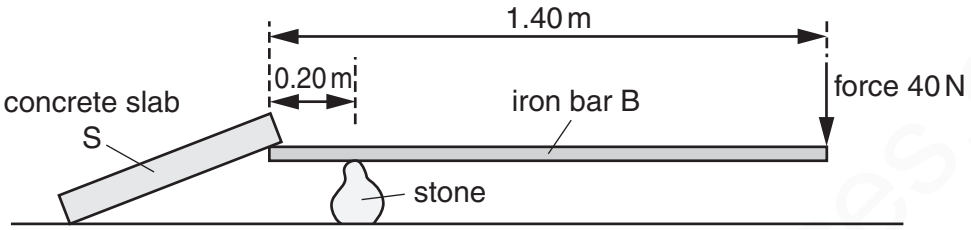

Fig. 3.1

(i) On Fig. 3.1, draw an arrow to show the weight of bar B acting from its centre of mass. [1]

(ii) State the distance *d* of the centre of mass of bar B from the pivot.

d = ...[1]

(iii) Calculate the total clockwise moment, about the pivot, of the forces acting on bar B.

total clockwise moment = ...[3]

(iv) Calculate the downward force which the slab S exerts on the end of bar B.

force = ...[2]

(v) Suggest a change to the arrangement in Fig. 3.1 that would reduce the force required to lift the slab.

.....

.....[1]

[Total: 9]

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(a) force AND
perpendicular distance (of force) from the point. B1

(b) **(i)** downward arrow at centre of bar B1

(ii) 0.5(0) m / 50 cm B1

(iii) 40 × 1.2 OR 48 seen anywhere C1
(+) 30 × 0.5 0R 15 seen anywhere C1
= 63 N m A1

(iv) $F \times 0.2 = 63$ C1
$F = 63/0.2 = 315$ N A1

(v) make bar / B longer
OR move pivot / stone to the left
OR increase distance between force and pivot (by moving pivot to left)
OR increase mass of the bar / B B1 [9]

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2 Fig. 2.1 shows a mobile bird sculpture that has been created by an artist.

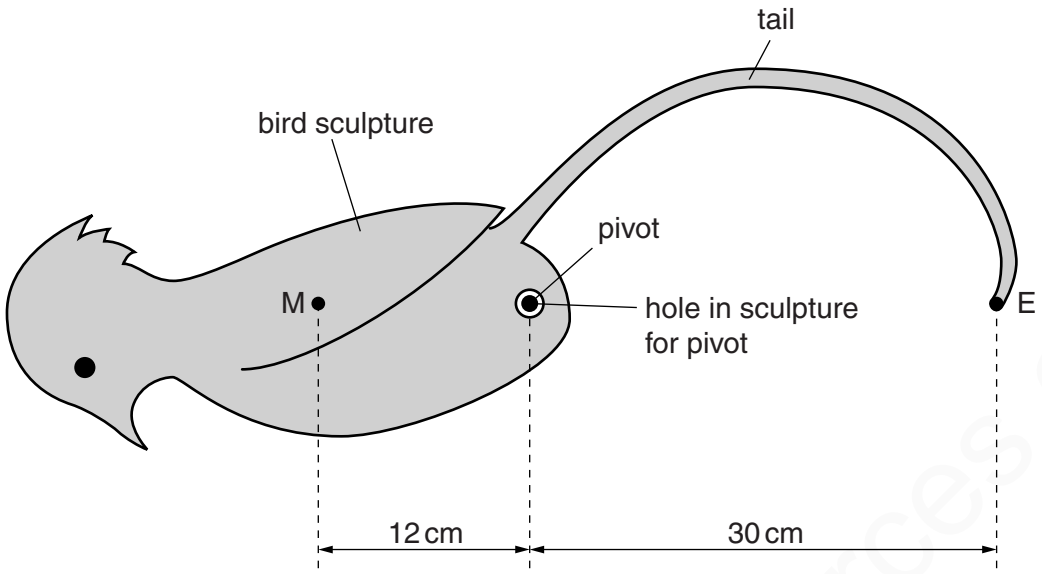

Fig. 2.1

M is the centre of mass of the bird sculpture, including its tail (but not including the counter-weight that will be added later). The mass of the bird and tail is 1.5 kg.

The bird sculpture is placed on a pivot.

The artist adds the counter-weight at the end E of the tail so that the bird remains stationary in the position shown.

(a) Calculate the mass of the counter-weight.

mass = ... [2]

(b) The centre of mass of the sculpture with counter-weight is at the pivot.

Calculate the upward force acting at the pivot.

force = ... [1]

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(c) The sculpture is rotated clockwise to the position shown in Fig. 2.2. It is held still, then carefully released.

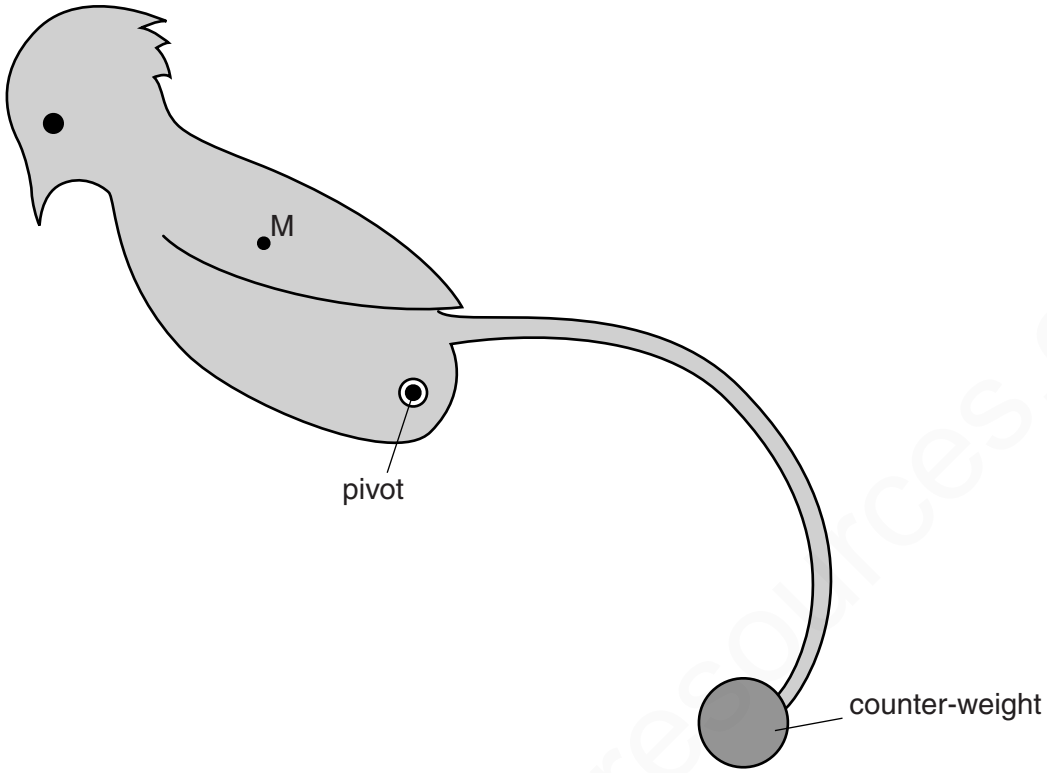

Fig. 2.2

(i) State whether the sculpture will stay in that position, rotate further clockwise or rotate back anticlockwise.

.....

.....

(ii) Explain your answer to **(i)**.

.....

.....

.....

.....

[3]

[Total: 6]

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MARKING SCHEME:

(a) mass = (1.5 × 10 × 12)/(30 × 10) OR = (1.5 × 12)/30 — C1
OR any correct moment equation with force or mass but not mixture
= 0.6(0) kg — A1 [2]

(b) 21 N ecf from **(a)** — B1 [1]

(c) **(i)** stays in position — B1

(ii) any two from:

- clockwise moment = anticlockwise moment — B1
- centre of mass at pivot — B1
- no (resultant) moment/turning force acting on sculpture
- balanced/in equilibrium
- relative distances from pivot unchanged [3]

[Total: 6]

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3 A metre rule balances when the 50 cm mark is directly above a pivot.

(a) State where in the rule its centre of mass is located.

.....

..... [1]

(b) Fig. 3.1 shows an apple and a 0.40 N weight placed on the rule so that the rule remains balanced at the 50 cm mark.

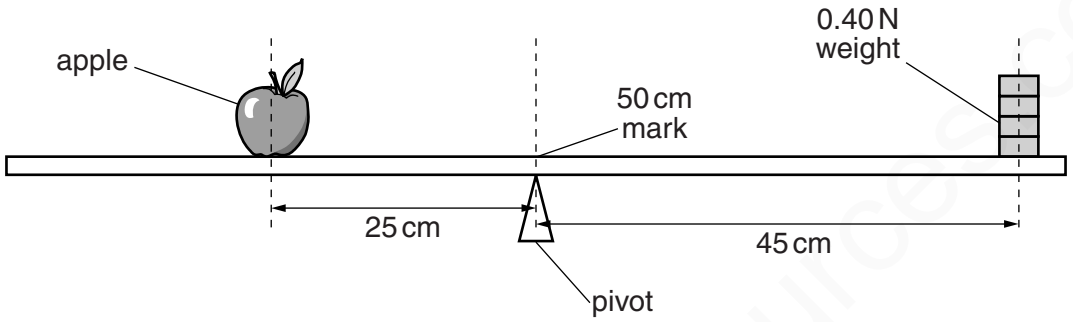

Fig. 3.1 (not to scale)

The centre of mass of the apple is 25 cm from the pivot and the centre of mass of the weight is 45 cm from the pivot.

Calculate

(i) the weight of the apple,

weight = ... [2]

(ii) the mass of the apple.

mass = ... [1]

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(c) The apple is not moved. The weight is removed from the rule and the pivot is moved to the left until the rule balances as shown in Fig. 3.2.

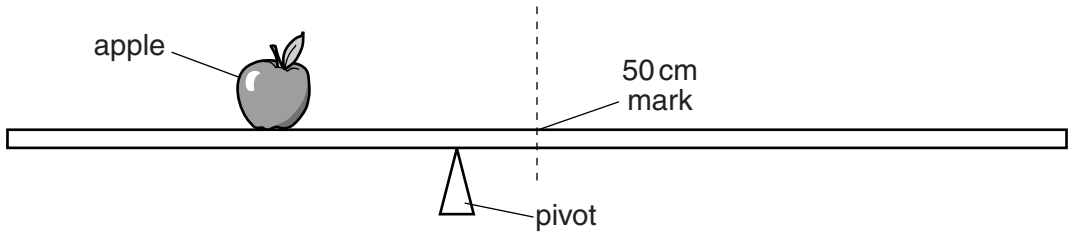

Fig. 3.2 (not to scale)

(i) Explain why the arrangement in Fig. 3.2 balances.

.....

.....

..... [2]

(ii) The pivot in Fig. 3.2 is closer to the 50 cm mark than to the centre of mass of the apple.

Compare the weight of the rule to the weight of the apple.

.....

..... [1]

[Total: 7]

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MARKING SCHEME:

(a)		(immediately below / above the / at) 50 cm mark **OR** at pivot	B1
(b)	**(i)**	anticlockwise moment = clockwise moment **OR** $45 \times 0.40 = 25 \times W$	C1
		0.72 N	A1
	(ii)	0.072 kg **OR** 72 g e.c.f from **(b)(i)**	B1
(c)	**(i)**	no net moment **OR** two moments cancel	C1
		moment due to weight of rule cancels moment due to weight of apple	A1
	(ii)	weight of the rule / it is bigger	B1

[Total: 7]

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4 **(a)** A loose uniform wooden floorboard weighs 160 N and rests symmetrically on four supports P, Q, R and S.

The supports are 0.50 m apart, as shown in Fig. 2.1.

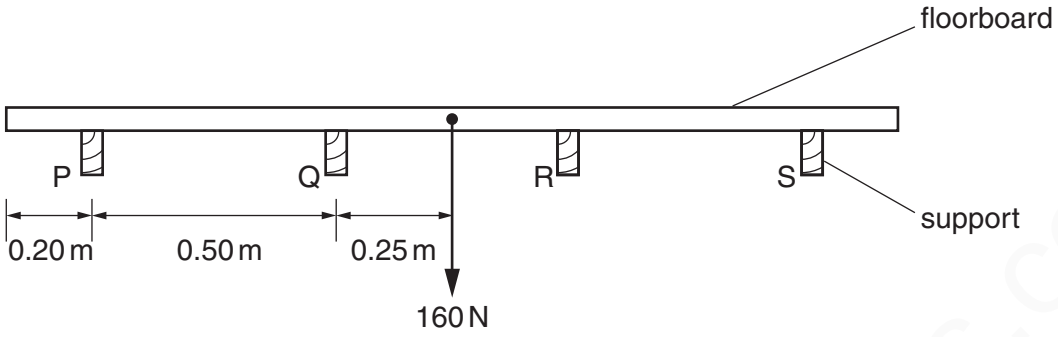

Fig. 2.1

Calculate the force exerted on the floorboard by each of the supports, and state the direction of these forces. One value is already given for you.

force exerted by P = ...

force exerted by Q = 40 N

force exerted by R = ...

force exerted by S = ...

direction = ... [2]

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(b) A workman of weight *W* stands on the end of the floorboard described in **(a)**.

This just causes the floorboard to tip up, as shown in Fig. 2.2.

The supports are each 0.060 m thick.

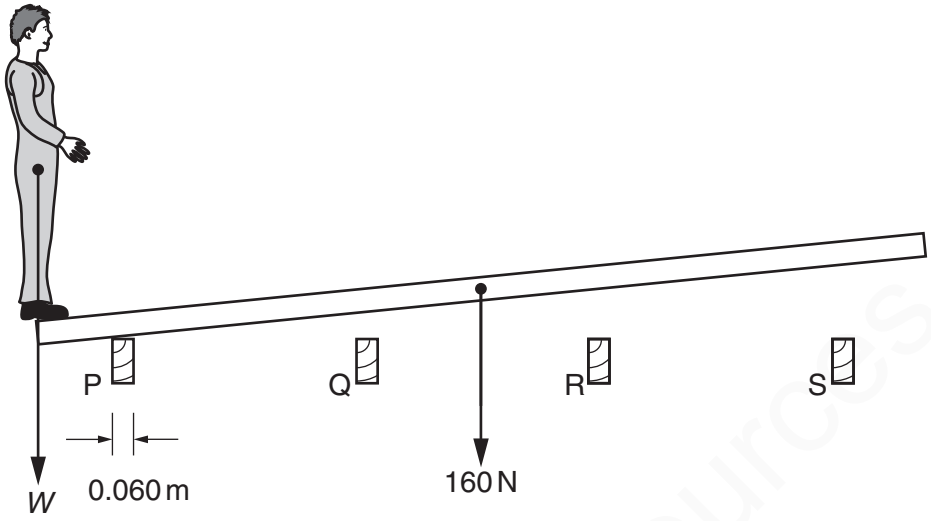

Fig. 2.2

(i) Calculate the weight *W* of the workman.

weight *W* = ... [3]

(ii) Calculate the force that each of the supports now exerts on the floorboard.

force exerted by P = ...

force exerted by Q = ...

force exerted by R = ...

force exerted by S = ... [2]

[Total: 7]

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MARKING SCHEME:

(a)	all four = 40 N OR all four add up to 160 N		B1
	upwards		B1
(b)	**(i)**	W × 0.17/0.20/0.23 = 160 × 0.72/0.75/0.78	C1
		W × 0.17 = 160 × 0.78 **or** 600 N	C1
		730/734 N	A1
	(ii)	force by P = 160 + answer to **(i)** correctly evaluated	B1
		all others = 0	B1

[Total: 7]

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5 **(a)** State the two conditions required for the equilibrium of a body acted upon by a number of forces.

1. .....

.....

2. .....

.....[2]

(b) Fig. 3.1 shows a diagram of an arm with the hand holding a weight of 120 N.

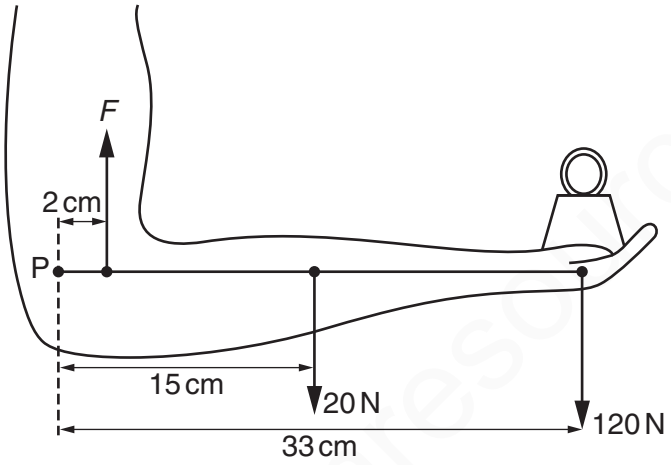

Fig. 3.1

The 20 N force is the weight of the forearm, acting at its centre of mass. *F* is the force in the muscle of the upper arm. P is the point in the elbow about which the arm pivots. The distances of the forces from point P are shown.

(i) By taking moments about point P, calculate the force *F*.

force *F* = ...[3]

(ii) A force acts on the forearm at point P. Calculate this force and state its direction.

force = ...

direction = ...[2]

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MARKING SCHEME:

(a)	1.	no resultant force acts / no net force acts OR total force up / in any direction = total force down / in opposite direction allow sum of forces or resultant force for total force	B1	
	2.	no resultant moment / couple / torque acts OR (sum of) clockwise moments and (sum of) anti-clockwise moments (about any point / axis) balance	B1	
(b)	**(i)**	(anti-clockwise moment =) $F \times 2$	C1	
		(total clockwise moment =) $(120 \times 33) + (20 \times 15) = 4260$ (N cm)	C1	
		2130 N	A1	
	(ii)	1990 N OR candidate's **(b)(i)** – 140 N	B1	
		force is downwards	B1	[7]

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