MOMENT OF A FORCE

1 **(a)** A stationary body is acted upon by a number of forces. State the two conditions which must apply for the body to remain at rest.

1. ....

2. ....
[2]

(b) Fig. 3.1 shows a device used for compressing crushed material.

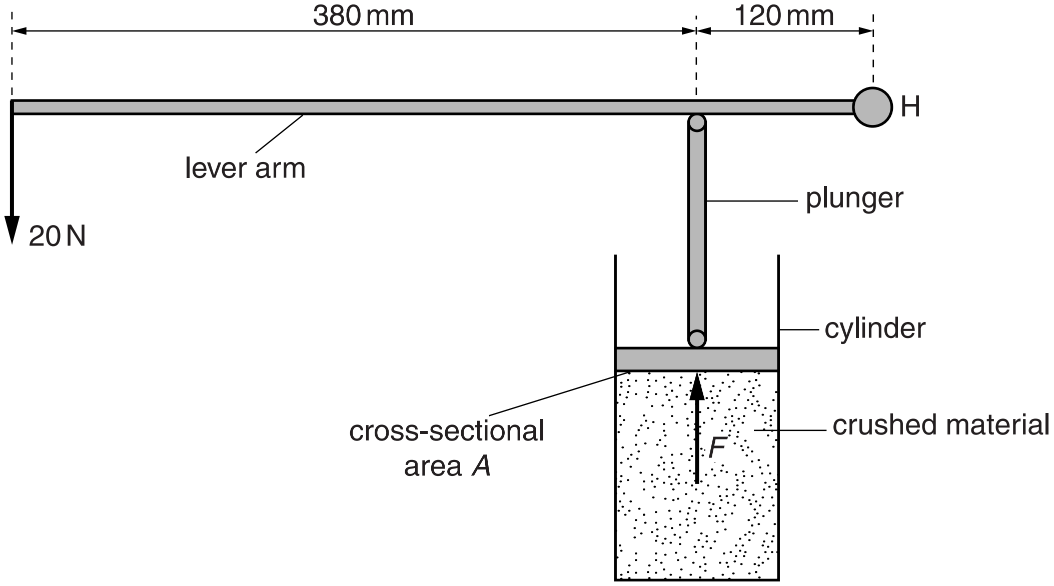

Fig. 3.1

The lever arm rotates about the hinge H at its right-hand end. A force of 20 N acts downwards on the left-hand end of the lever arm. The force *F* of the crushed material on the plunger acts upwards. Ignore the weight of the lever arm.

(i) Use the clockwise and anticlockwise moments about H to calculate the upward force *F* which the crushed material exerts on the plunger. The distances are shown on Fig. 3.1.

force *F* = ... [3]

(ii) The cross-sectional area *A* of the plunger in contact with the crushed material is 0.0036 m^2. Calculate the pressure exerted on the crushed material by the plunger.

pressure = ... [2]

[Total: 7]

MARKING SCHEME:

(a)		No resultant/net force OR no resultant force in any direction OR no resultant force in any two perpendicular directions	B1	
		No resultant/net moment/turning effect/couple/torque OR (total) clockwise moment = (total) anticlockwise moment	B1	
		Either order		
(b)	**(i)**	F × 120 / F × 0.12	C1	
		= 20 × 500 OR 20 × 0.5	C1	
		F = 83.3 N at least 2 significant figures. Allow $83^1/_3$ *Unit penalty applies	A1	
	(ii)	F/A or in words OR 83.3/0.0036 ecf from **(b)(i)**	C1	
		= 23100 Pa / N/m^2 OR 2.31 N/cm^2 OR 23.1 kPa *Unit penalty applies	A1	**[7]**

2 **(a)** **(i)** Write down the names of **three** man-made devices in everyday use that depend, for their action, upon the moments of forces.

1. ....

2. ....

3. ....
[2]

(ii) Fig. 3.1 shows a uniform rod AB acted upon by three equal forces *F*.

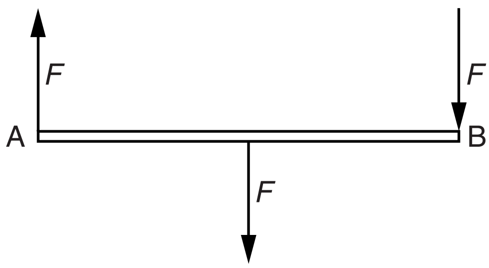

Fig. 3.1

State **two** reasons why the rod is **not** in equilibrium.

1. ....

2. ....
[2]

(b) Fig. 3.2 shows a uniform rod PQ, supported at its centre and held in a horizontal position. The length of PQ is 1.00 m.

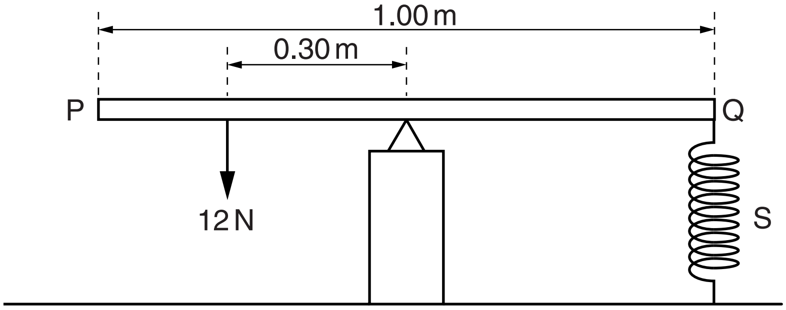

Fig. 3.2

A force of 12 N acts at a distance of 0.30 m from the support. A spring S, fixed at its lower end, is attached to the rod at Q.

(i) Calculate the force exerted on PQ by the spring.

force = ... [2]

(ii) Explain why it is not necessary to know the weight of PQ.

....

.... [1]

[Total: 7]

MARKING SCHEME:

(a)	**(i)**	3 appropriate examples: e.g. spanner, scissors, tap etc. –1e.e.o.o.	B2
	(ii)	there is a resultant force OR more force down than up	B1
		there is a resultant moment OR clockwise moment is not equal to anticlockwise moment	B1
(b)	**(i)**	$F \times 0.5 = 12 \times 0.3$	C1
		7.2 N	A1
	(ii)	weight has no moment about centre of rod / has no perpendicular distance from centre of rod OR weight acts at centre of rod / pivot / centre of mass	B1

[Total: 7]

3 Fig. 2.1 shows a uniform, rectangular slab of concrete ABCD standing upright on the ground. The slab has height 0.60 m, width 0.30 m and mass 18 kg. A force of 40 N acts horizontally to the left at B.

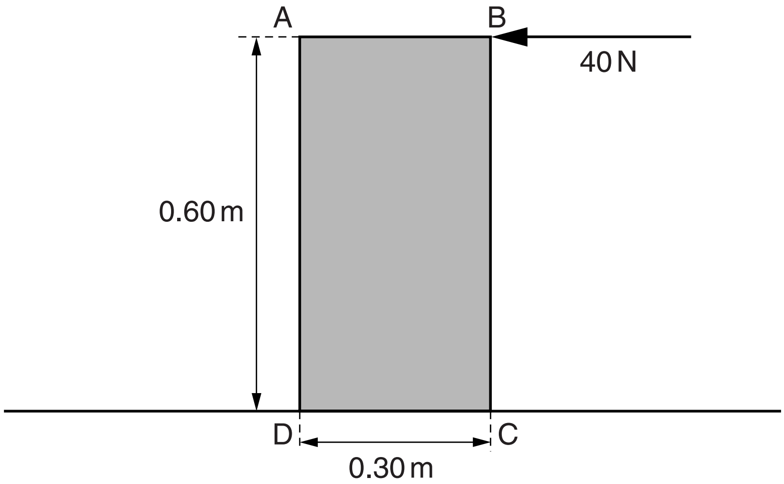

Fig. 2.1

(a) (i) Calculate the weight *W* of the concrete slab.

W = ... [1]

(ii) The thickness of the slab is 0.040 m.

Calculate the pressure exerted by the slab on the ground.

pressure = ... [2]

(b) (i) On Fig. 2.1, draw and label an arrow to show the weight *W* of the slab acting at its centre of mass. [1]

(ii) Calculate

1. the moment of the 40 N force about point D,

moment = ...

2. the moment of *W* about point D.

moment = ...
[3]

(iii) The ground is rough so that the slab does not slide.

State and explain what happens to the slab as the horizontal force at B is gradually increased.

....

....

....[2]

[Total: 9]

MARKING SCHEME:

(a)	**(i)**	180 N		B1
	(ii)	(*P* =) *F* ÷ *A* **OR** 180÷(0.30 × 0.04) 15 000 Pa		C1 A1
(b)	**(i)**	arrow (labelled *W*) from / to correct centre of mass		B1
	(ii)	**1.** force × (perpendicular) distance **OR** 40 × 0.60 **OR** 180 × 0.15 in **2.** 24 N m		C1 A1
		2. 27 N m	e.c.f. from **(a)(i)**	A1
	(iii)	slab topples / rotates (about point D) **OR** corner C lifts from ground **OR** falls over		B1
		moment of force at B becomes bigger than moment of weight / W **OR** anticlockwise moment becomes bigger than clockwise moment **OR** weight/centre of mass outside base		B1

[Total: 9]

4 **(a)** A uniform metre rule is pivoted at its centre, which is also the position of its centre of mass.

Three loads, 2.0 N, *F* and 3.0 N are positioned on the rule at the 20 cm, 30 cm and 90 cm marks respectively, as shown in Fig. 3.1.

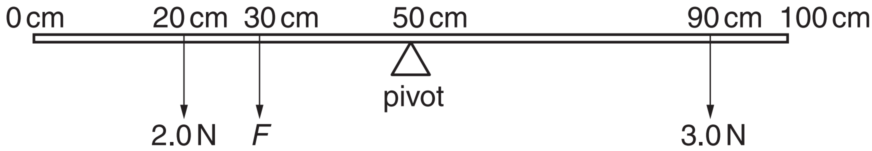

Fig. 3.1

(i) Calculate the moment of the 3.0 N load about the pivot.

moment = ... [1]

(ii) Calculate the moment of the 2.0 N load about the pivot.

moment = ... [1]

(iii) The force *F* maintains the metre rule in equilibrium on the pivot.

Calculate the value of *F*.

F = ... [3]

(b) The weight of the metre rule is 1.2 N and can be considered to act at the 50 cm mark.

All the weights in **(a)** are removed. The pivot is positioned under the 30 cm mark and the 2.0 N load is placed on the rule as shown in Fig. 3.2.

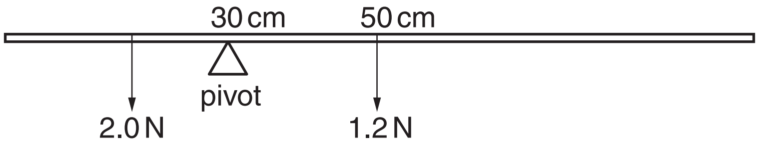

Fig. 3.2

The position of the 2.0 N load is adjusted until the metre rule is again in equilibrium.

Determine the position of the 2.0 N load.

2.0 N load is at the .... cm mark [3]

[Total: 8]

(a) **(i)**	120 Ncm OR 1.2 Nm	B1
(ii)	60 Ncm OR 0.6 Nm	B1
(iii)	idea of CW moments = ACW moments	C1
	60 + 20*F* = 120 OR 0.6 + 0.2*F* = 1.2 e.c.f.	C1
	3.0 N OR 3 N e.c.f.	A1
(b)	1.2 × 20 = 2.0 × *d* OR 1.2 × 0.2 = 2.0 × *d*	C1
	(*d* =) 12 OR 0.12	C1
	18 c.a.o. OR special case (30 – his 12) correctly evaluated B1	A1

[Total: 8]

5 Fig. 2.1 shows a circular metal disc of mass 200 g, freely pivoted at its centre.

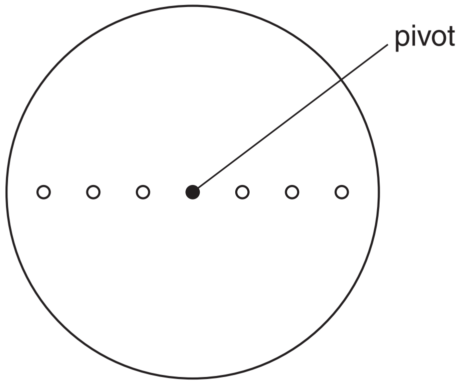

Fig. 2.1

Masses of 100 g, 200 g, 300 g, 400 g, 500 g and 600 g are available, but only one of each value. These may be hung with string from any of the holes. There are three small holes on each side of the centre, one at 4.0 cm from the pivot, one at 8.0 cm from the pivot and one at 12.0 cm from the pivot.

The apparatus is to be used to show that there is no net moment of force acting on a body when it is in equilibrium.

(a) On Fig. 2.1, draw in **two different** value masses hanging from appropriate holes. The values of the masses should be chosen so that there is no net moment. Alongside the masses chosen, write down their values. [2]

(b) Explain how you would test that your chosen masses give no net moment to the disc.

....

....

....

.... [1]

(c) Calculate the moments about the pivot due to the two masses chosen.

moment due to first mass = ...

moment due to second mass = ...
[2]

(d) Calculate the force on the pivot when the two masses chosen are hanging from the disc.

force = ... [2]

[Total: 7]

(a)	two masses chosen with ratio 2:1 or 3:1 or 3:2 chosen masses in correct holes to balance	M1 A1	
(b)	disc does not rotate/is balanced/in equilibrium/no movement NOT spin the disc NOT anything to do with calculating moments NOT when disturbed, returns to original position	B1	
(c)	moment of one mass correct (ignore units) accept mass × distance calculated equal answers	 B1 B1	
(d)	correct addition of masses/weights, including 200 g any mass correctly converted to N	B1 B1	[7]

6 **(a)** State the two conditions necessary for a system of forces acting on a body to be in equilibrium.

1. ....

....

2. ....

.... [2]

(b) Fig. 1.1 shows a loaded wheelbarrow held in equilibrium by a gardener. The wheel of the wheelbarrow is in contact with the ground at point C.

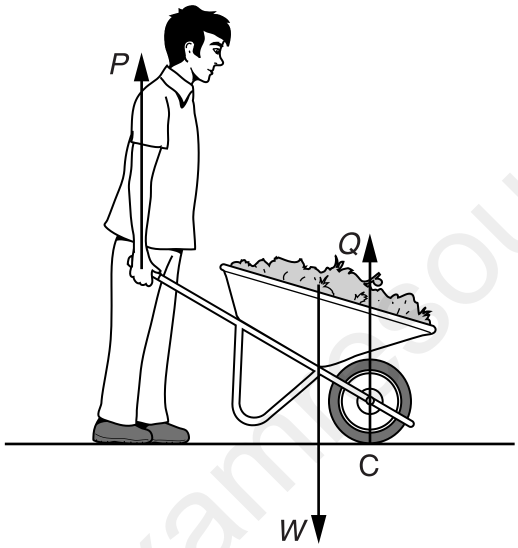

Fig. 1.1

In Fig. 1.1, there are three vertical forces acting on the wheelbarrow.

P is the upward force applied by the gardener.
Q is the upward force of the ground on the wheel at point C.
W is the weight of the wheelbarrow and its contents.

Explain why the force *P* is less than the force *W*

(i) by considering the forces *P, Q* and *W*,

....

.... [2]

(ii) by considering the moments of the forces *P* and *W* about point C.

....

.... [2]

(c) Fig. 1.2 shows a kitchen cupboard resting on a support and attached to a wall by a screw.

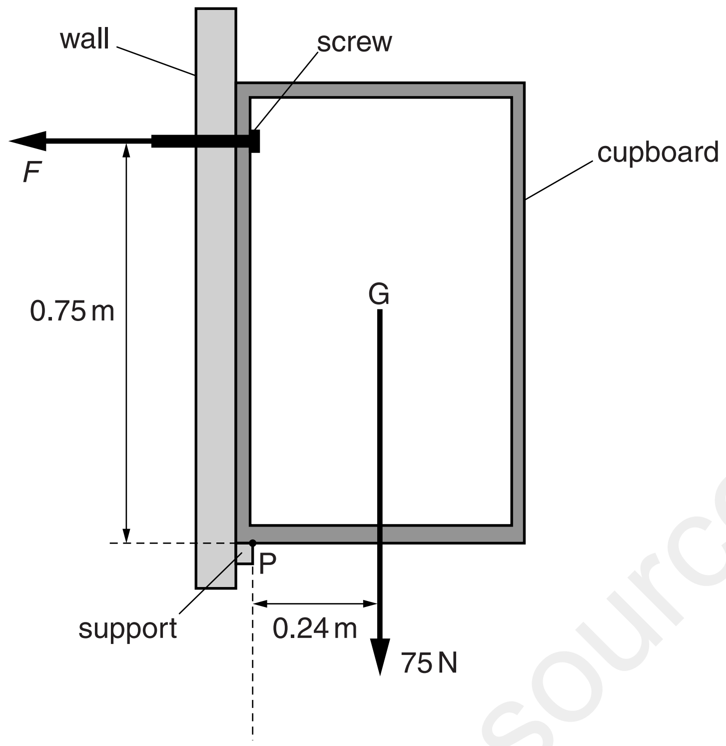

Fig. 1.2

The weight of the cupboard and its contents is 75 N. G is the position of the centre of mass of the cupboard.

The clockwise and anticlockwise moments about point P are equal.

Calculate the force *F* exerted by the screw.

F = ... [3]

[Total: 9]

(a)		no resultant/net force (acting)	B1
		no resultant/net moment (acting) **OR** clockwise moment = anticlockwise moment	B1
(b)	**(i)**	*W* = *P* + *Q* in any form **OR** (total) upward force = (total) downward force	B1
		P = *W* – *Q* so *P* must be less than *W* **OR** *P* is not the only upward force	B1
	(ii)	*P* × its distance (from C)=*W* × its distance (from C) **OR** *P* and *W* have equal moments (about C) **OR** clockwise moment = anticlockwise moment	B1
		P is farther from C/pivot (than *W* so *P* must be less than *W*)	B1
(c)		clockwise moment = 75 × 0.24	C1
		anticlockwise moment = *F* × 0.75	C1
		(moments equated gives *F* =) 24 N	A1
			[Total: 9]

7 **(a)** Complete the following statement.

An object is in equilibrium when both the .... and the

.... on the object are zero. [2]

(b) Fig. 3.1 shows a ladder AB. End A of the ladder rests against a vertical wall. End B rests on rough ground.

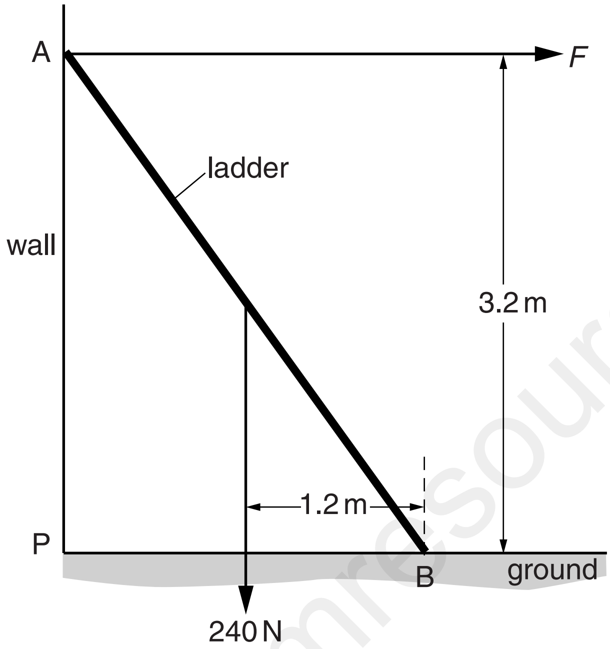

Fig. 3.1

Fig. 3.1 shows two of the forces acting on the ladder. The only force on the ladder at A is *F*, which acts at right-angles to the wall. The weight of the ladder is 240 N acting at the centre of mass of the ladder.

(i) **1.** Calculate the moment of the weight of the ladder about point B.

moment = ... [1]

2. Write an expression, in terms of *F*, for the moment of *F* about point B.

moment = ... [1]

(ii) Use your answers from **(i)** to calculate *F*.

F = ... [2]

(iii) Explain why there must be an upwards force acting on the ladder at B.

....

.... [1]

[Total: 7]

(a)	Note: answers in either order	
	Resultant/net/total force	B1
	Resultant/net/ total turning effect/moment/torque/couple	B1
(b) (i)	**1.** (240 × 1.2 =) 290 (N m)	B1
	2. $F \times 3.2$	B1
(ii)	$F \times 3.2 = 288$	C1
	90 N	A1
(iii)	To balance the weight OR to make resultant (vertical) force zero OR to make resultant moment zero OR to keep the ladder in (vertical) equilibrium OR because there is a downward force OR because the ladder is pressing on the ground OR otherwise the ladder would fall / sink (into the ground)	B1

[Total: 7]