1 **(a)** State the two conditions necessary for the equilibrium of a body which is acted upon by a number of forces.

1. .....

.....

2. .....

.....[2]

(b) Three identical springs S_1, S_2 and S_3 are attached to a point A such that the angle between any two of the springs is 120°, as shown in Fig. 3.1.

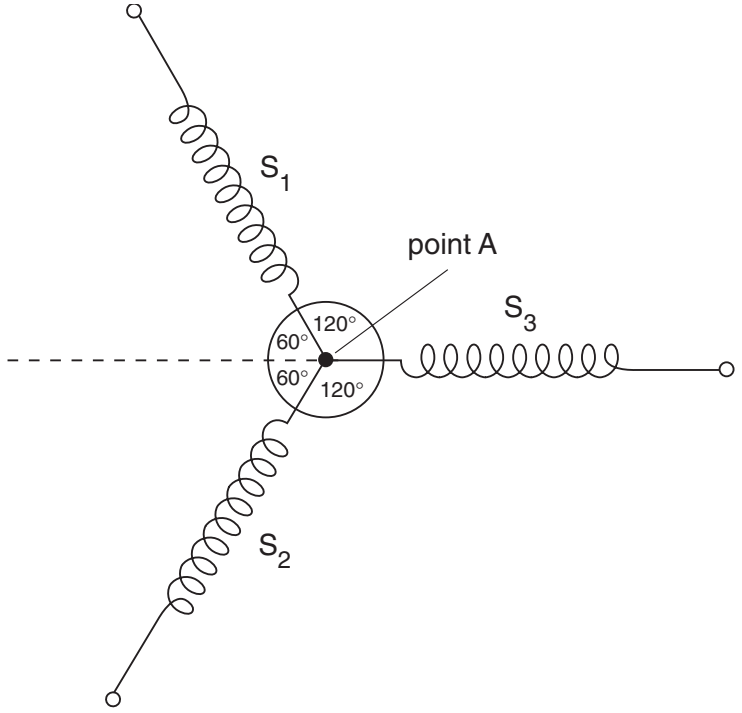

Fig. 3.1

The springs have extended elastically and the extensions of S_1 and S_2 are x. Determine, in terms of x, the extension of S_3 such that the system of springs is in equilibrium. Explain your working.

extension of S_3 = ... [3]

(c) The lid of a box is hinged along one edge E, as shown in Fig. 3.2.

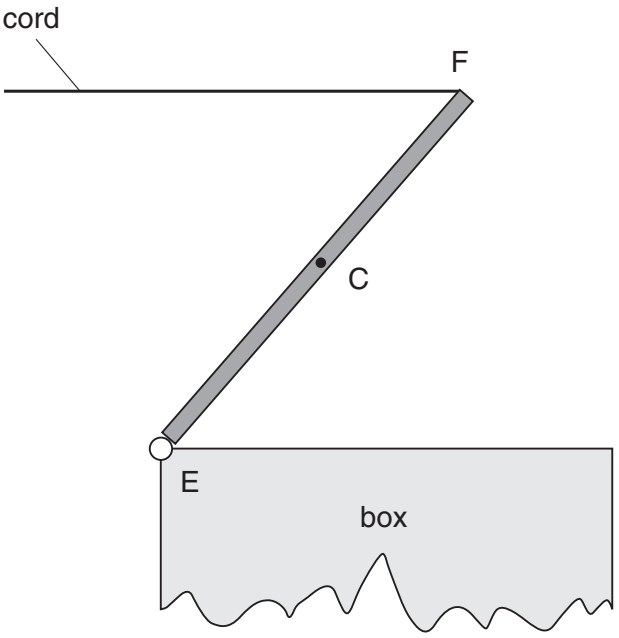

Fig. 3.2

The lid is held open by means of a horizontal cord attached to the edge F of the lid. The centre of gravity of the lid is at point C.

On Fig. 3.2 draw

(i) an arrow, labelled W, to represent the weight of the lid,

(ii) an arrow, labelled T, to represent the tension in the cord acting on the lid,

(iii) an arrow, labelled R, to represent the force of the hinge on the lid.

[3]

2 **(a)** Explain what is meant by the *centre of gravity* of an object.

.....

.....

.....[2]

(b) A non-uniform plank of wood XY is 2.50 m long and weighs 950 N. Force-meters (spring balances) A and B are attached to the plank at a distance of 0.40 m from each end, as illustrated in Fig. 3.1.

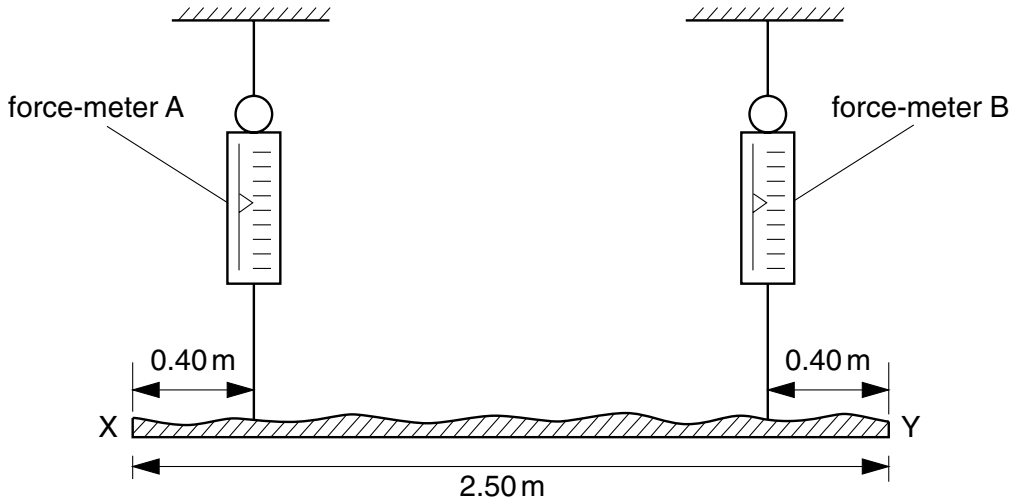

Fig. 3.1

When the plank is horizontal, force-meter A records 570 N.

(i) Calculate the reading on force-meter B.

reading = ... N

(ii) On Fig. 3.1, mark a likely position for the centre of gravity of the plank.

(iii) Determine the distance of the centre of gravity from the end X of the plank.

distance = ... m

[6]

3 Two forces, each of magnitude F, form a couple acting on the edge of a disc of radius r, as shown in Fig. 5.1.

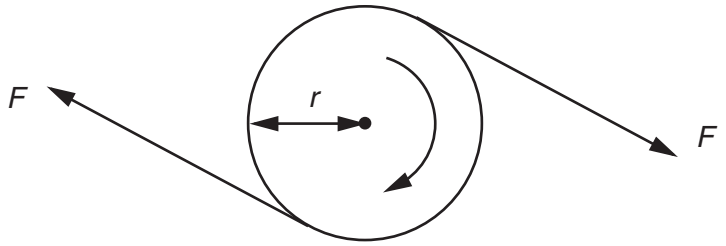

Fig. 5.1

(a) The disc is made to complete n revolutions about an axis through its centre, normal to the plane of the disc. Write down an expression for

(i) the distance moved by a point on the circumference of the disc,

distance = ...

(ii) the work done by one of the two forces.

work done = ...
[2]

(b) Using your answer to **(a)**, show that the work W done by a couple producing a torque T when it turns through n revolutions is given by

$$W = 2\pi nT.$$ [2]

(c) A car engine produces a torque of 470 N m at 2400 revolutions per minute. Calculate the output power of the engine.

power = ... W [2]

4 **(a)** Explain what is meant by the *centre of gravity* of a body.

.....

.....

..... [2]

(b) An irregularly-shaped piece of cardboard is hung freely from one point near its edge, as shown in Fig. 2.1.

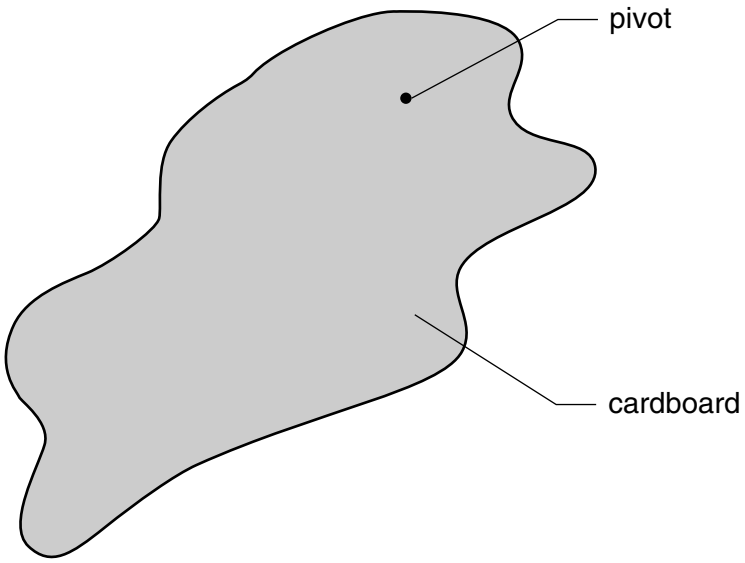

Fig. 2.1

Explain why the cardboard will come to rest with its centre of gravity vertically below the pivot. You may draw on Fig. 2.1 if you wish.

.....

.....

..... [2]

5 A stone on a string is made to travel along a horizontal circular path, as shown in Fig. 3.1.

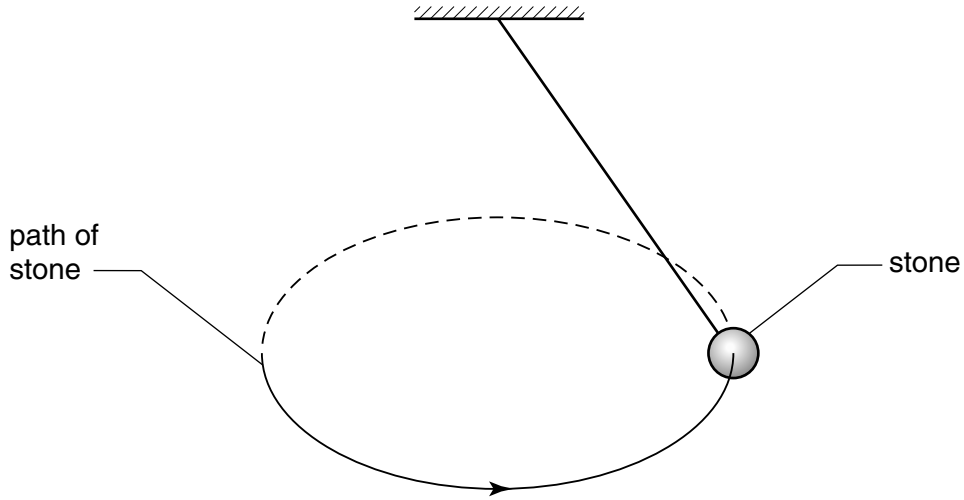

Fig. 3.1

The stone has a constant speed.

(a) Define *acceleration*.

.....

..... [1]

(b) Use your definition to explain whether the stone is accelerating.

.....

.....

..... [2]

(c) The stone has a weight of 5.0 N. When the string makes an angle of 35° to the vertical, the tension in the string is 6.1 N, as illustrated in Fig. 3.2.

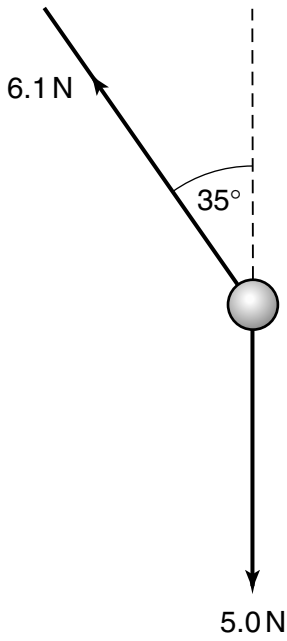

Fig. 3.2

Determine the resultant force acting on the stone in the position shown.

magnitude of force = ……..…….. N

direction of force…..……..…….. [4]

6 A rod AB is hinged to a wall at A. The rod is held horizontally by means of a cord BD, attached to the rod at end B and to the wall at D, as shown in Fig. 2.1.

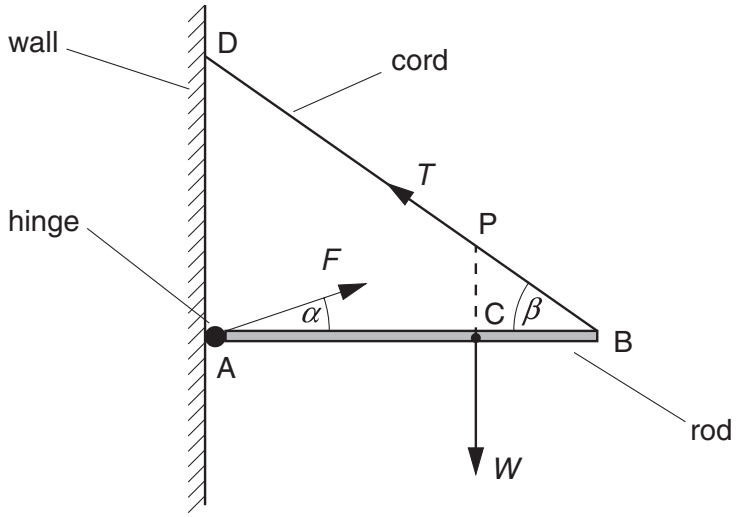

Fig. 2.1

The rod has weight *W* and the centre of gravity of the rod is at C. The rod is held in equilibrium by a force *T* in the cord and a force *F* produced at the hinge.

(a) Explain what is meant by

(i) the *centre of gravity* of a body,

.....

.....

..... [2]

(ii) the *equilibrium* of a body.

.....

.....

.....

..... [2]

(b) The line of action of the weight W of the rod passes through the cord at point P.

Explain why, for the rod to be in equilibrium, the force F produced at the hinge must also pass through point P.

.....

.....

.....

..... [2]

(c) The forces F and T make angles α and β respectively with the rod and AC = $\frac{2}{3}$AB, as shown in Fig. 2.1.

Write down equations, in terms of F, W, T, α and β, to represent

(i) the resolution of forces horizontally,

..... [1]

(ii) the resolution of forces vertically,

..... [1]

(iii) the taking of moments about A.

..... [1]

7 **(a)** Distinguish between the moment of a force and the torque of a couple.

moment of a force .....

.....

.....

torque of a couple .....

.....

.....

[4]

(b) One type of weighing machine, known as a steelyard, is illustrated in Fig. 3.1.

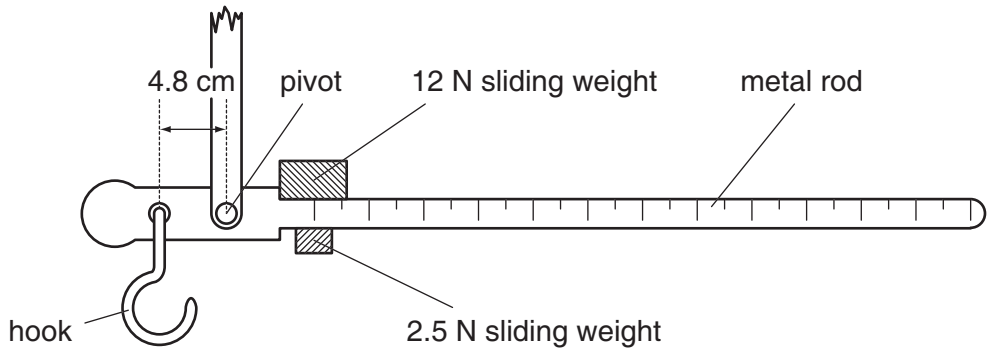

Fig. 3.1

The two sliding weights can be moved independently along the rod.

With no load on the hook and the sliding weights at the zero mark on the metal rod, the metal rod is horizontal. The hook is 4.8 cm from the pivot.

A sack of flour is suspended from the hook. In order to return the metal rod to the horizontal position, the 12 N sliding weight is moved 84 cm along the rod and the 2.5 N weight is moved 72 cm.

(i) Calculate the weight of the sack of flour.

weight = ……N [2]

(ii) Suggest why this steelyard would be imprecise when weighing objects with a weight of about 25 N.

.....

.....[1]