2 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.

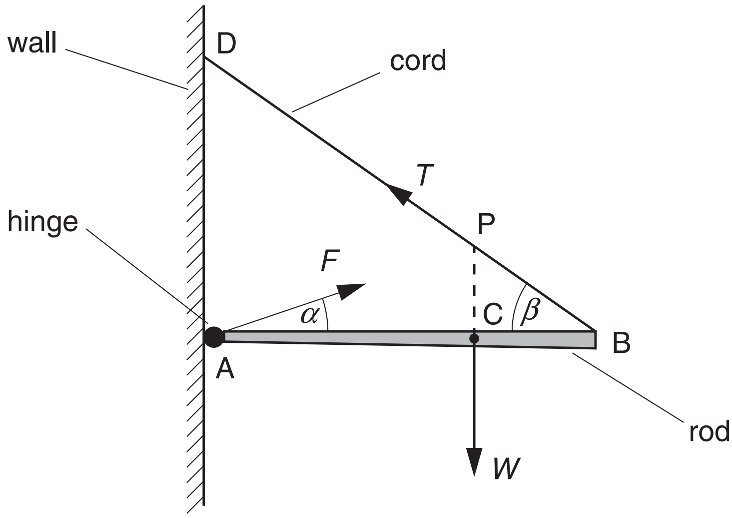

Fig. 2.1

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]

For Examiner's Use

4 **(a)** Define *density*.

....

....

.... [1]

(b) A U-tube contains some mercury. Water is poured into one arm of the U-tube and oil is poured into the other arm, as shown in Fig. 4.1.

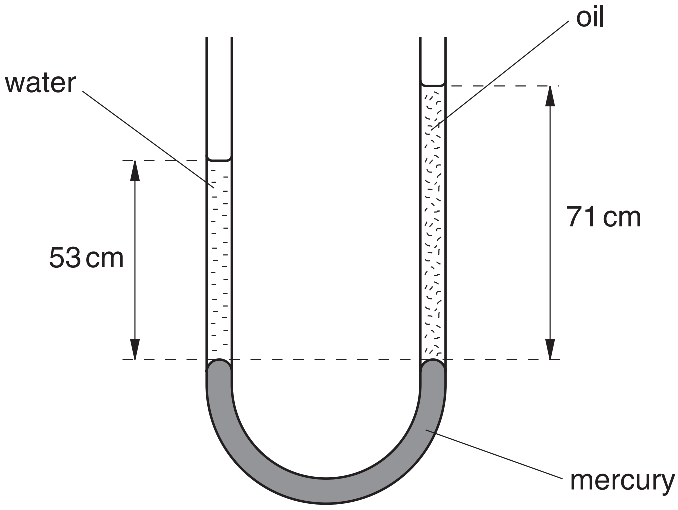

Fig. 4.1

The amounts of oil and water are adjusted until the surface of the mercury in the two arms is at the same horizontal level.

(i) State how it is known that the pressure at the base of the column of water is the same as the pressure at the base of the column of oil.

....

.... [1]

(ii) The column of water, density $1.0 \times 10^3\,\text{kg}\,\text{m}^{-3}$, is 53 cm high. The column of oil is 71 cm high.

Calculate the density of the oil. Explain your working.

density = ... $\text{kg}\,\text{m}^{-3}$ [3]

For Examiner's Use

2 **(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.

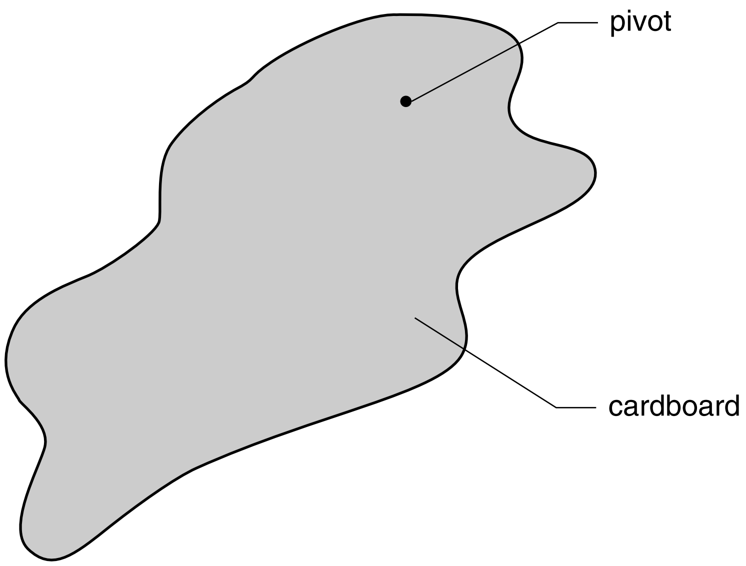

Fig. 2.1

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)** A metal wire has an unstretched length L and area of cross-section A. When the wire supports a load F, the wire extends by an amount ΔL. The wire obeys Hooke's law.

Write down expressions, in terms of L, A, F and ΔL, for

(i) the applied stress,

....

(ii) the tensile strain in the wire,

....

(iii) the Young modulus of the material of the wire.

....
[3]

(b) A steel wire of uniform cross-sectional area $7.9 \times 10^{-7}\ \text{m}^2$ is heated to a temperature of 650 K. It is then clamped between two rigid supports, as shown in Fig. 5.1.

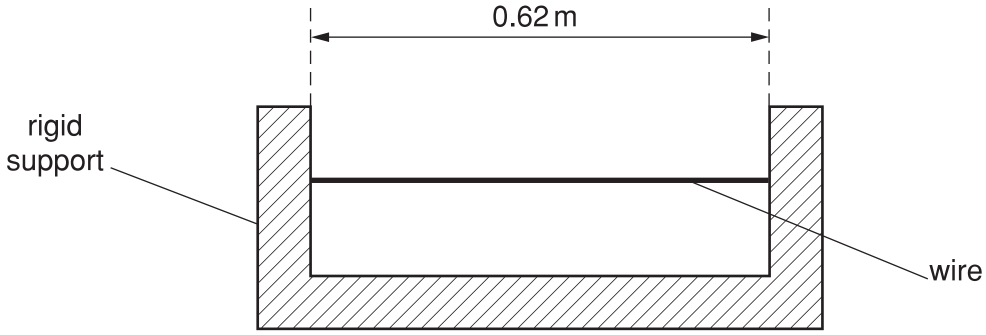

Fig. 5.1

The wire is straight but not under tension and the length between the supports is 0.62 m. The wire is then allowed to cool to 300 K.

When the wire is allowed to contract freely, a 1.00 m length of the wire decreases in length by 0.012 mm for every 1 K decrease in temperature.

(i) Show that the change in length of the wire, if it were allowed to contract as it cools from 650 K to 300 K, would be 2.6 mm.

[2]

For Examiner's Use

(ii) The Young modulus of steel is 2.0×10^{11} Pa. Calculate the tension in the wire at 300 K, assuming that the wire obeys Hooke's law.

tension = ... N [2]

(iii) The ultimate tensile stress of steel is 250 MPa. Use this information and your answer in **(ii)** to suggest whether the wire will, in practice, break as it cools.

....

.... [3]

Answer **all** the questions in the spaces provided.

1 **(a)** State the difference between a scalar quantity and a vector quantity.

scalar: ....

....

vector: ....

.... [2]

(b) Two forces of magnitude 6.0 N and 8.0 N act at a point P. Both forces act away from point P and the angle between them is 40°.
Fig. 1.1 shows two lines at an angle of 40° to one another.

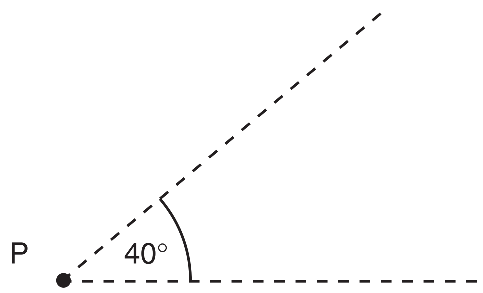

Fig. 1.1

On Fig. 1.1, draw a vector diagram to determine the magnitude of the resultant of the two forces.

magnitude of resultant = ... N [4]

5 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.

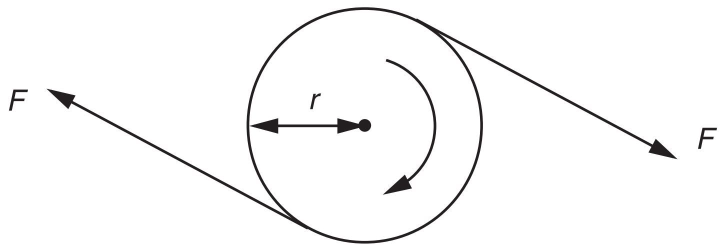

Fig. 5.1

(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

$$W = 2\pi n T.$$

[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]