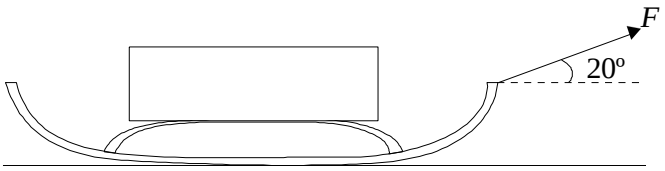
1. A heavy sledge is pulled across snowfields. The diagram shows the direction of the force *F* exerted on the sledge. Once the sledge is moving, the average horizontal force needed to keep it moving at a steady speed over level ground is 300 N.



(a) Calculate the force *F* needed to produce a horizontal component of 300 N on the sledge.

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(1)

(b) (i) Explain why the work done in pulling the sledge **cannot** be calculated by multiplying *F* by the distance the sledge is pulled.

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(ii) Calculate the work done in pulling the sledge a distance of 8.0 km over level ground.

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(iii) Calculate the average power used to pull the sledge 8.0 km in 5.0 hours.

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(6)

(c) The same average power is maintained when pulling the sledge uphill. Explain **in terms of energy transformations** why it would take longer than 5.0 hours to cover 8.0 km uphill.

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(3)

(Total 10 marks)

2. (a) State the condition necessary for the equilibrium of three coplanar forces acting at a point.

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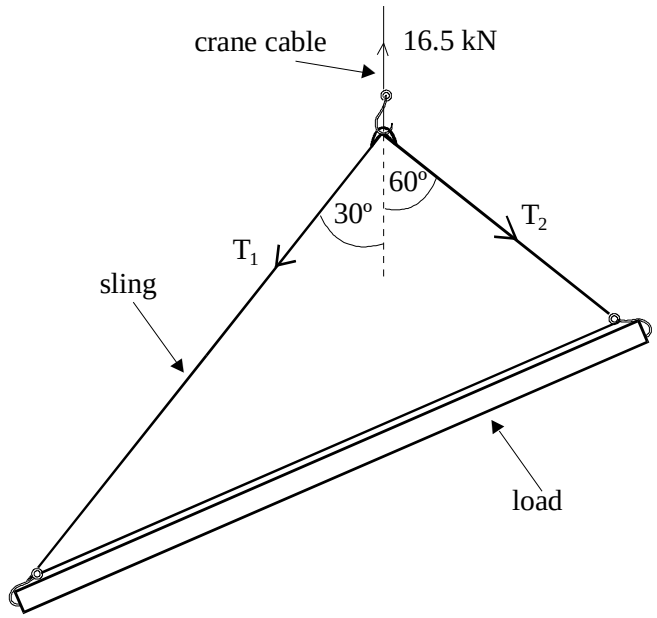
(1)

(b) The diagram shows a crane hook in equilibrium under the action of a vertical force of 16.5 kN in the crane cable and tension forces T_1 and T_2 in the sling.



Find the tension forces T_1 and T_2 acting in the sling. You may **either** calculate these forces **or** find them by scale drawing. In either case you should show your method clearly.

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T_1 = ...

.....

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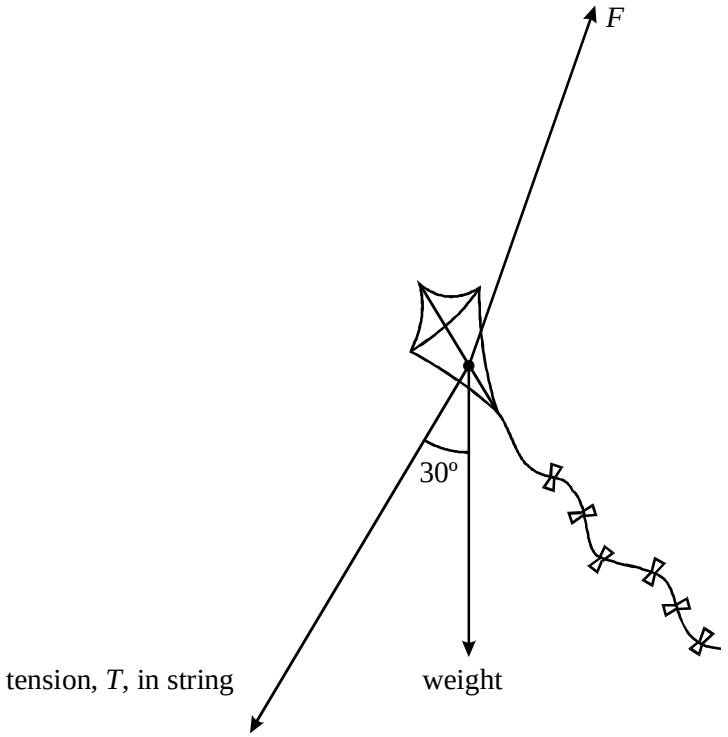
T_2 = ...

(4)
(Total 5 marks)

3. The diagram shows the forces acting on a stationary kite. The force *F* is the force that the air exerts on the kite.



(a) Show on the diagram how force *F* can be resolved into horizontal and vertical components.

(2)

(b) The magnitude of the tension, *T*, is 25 N.
Calculate

(i) the horizontal component of the tension,

.....

(ii) the vertical component of the tension.

.....

(2)

(c) (i) Calculate the magnitude of the vertical component of *F* when the weight of the kite is 2.5 N.

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(ii) State the magnitude of the horizontal component of *F*.

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(iii) Hence calculate the magnitude of F.

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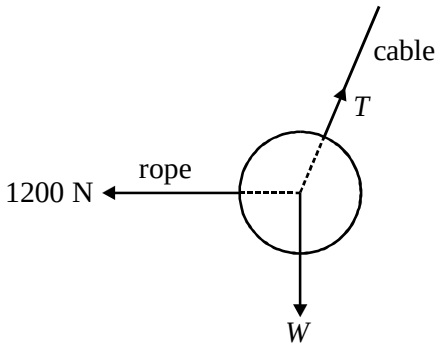
.....

(4)
(Total 8 marks)

4. The diagram shows a 250 kg iron ball being used on a demolition site. The ball is suspended from a cable at point A, and is pulled into the position shown by a rope that is kept horizontal. The tension in the rope is 1200 N.



(a) In the position shown the ball is in equilibrium.

(i) What balances the force of the rope on the ball?

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(ii) What balances the weight of the ball?

.....

(2)

(b) Determine

(i) the magnitude of the vertical component of the tension in the cable,

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(ii) the magnitude of the horizontal component of the tension in the cable,

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(iii) the magnitude of the tension in the cable,

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(iv) the angle the cable makes to the vertical.

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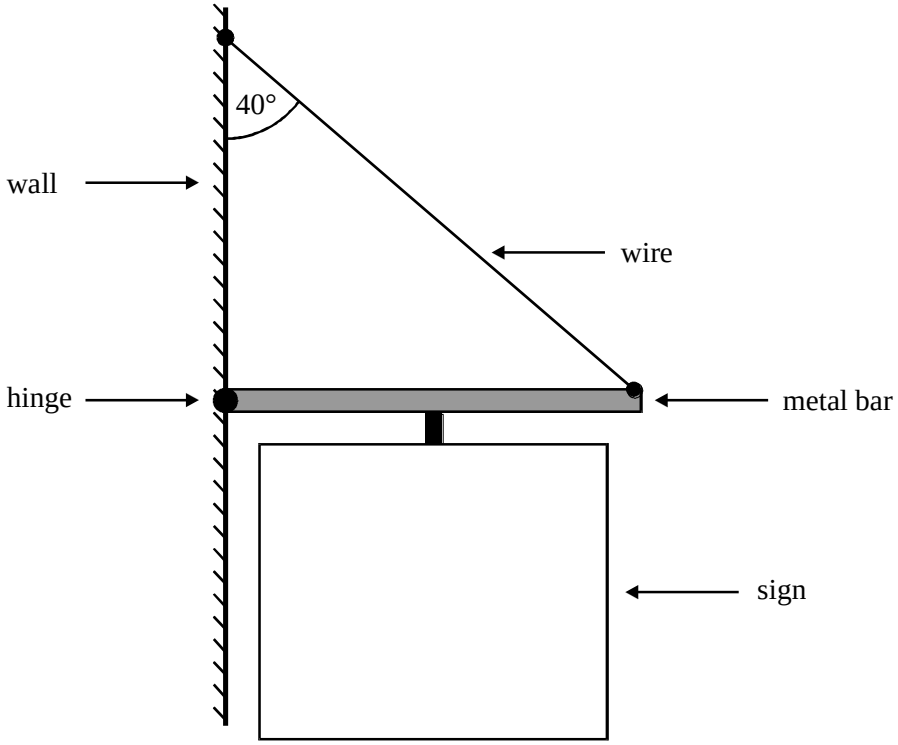
(6)
(Total 8 marks)

5. A public house sign is fixed to a vertical wall as shown in the diagram.



A uniform metal bar 0.75 m long is fixed to the wall by a hinged joint that allows free movement in the vertical plane only. The wire is fixed to the wall directly above the hinge and to the free end of the horizontal metal bar. The wire makes an angle of 40° with the wall. A single support holds the sign and is mounted at the mid point of the metal bar so that the weight of the sign acts through that point.

(a) (i) Draw on the diagram three arrows showing the forces acting on the metal bar, given that the system is in equilibrium. Label the arrows A, B and C.

(ii) State the origin of the forces.

A .....

B .....

C .....

(5)

(b) The combined mass of the metal bar and sign is 12 kg and the mass of the wire is negligible. By taking moments about the hinged end of the bar, or otherwise, calculate the tension in the wire.

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(4)
(Total 9 marks)

6. (a) State the principle of moments.

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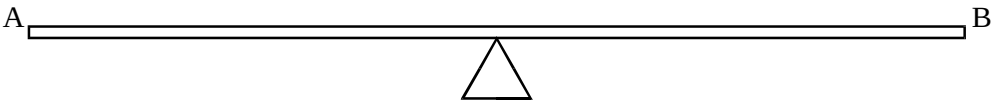
(2)

(b) The diagram shows a uniform metre ruler, AB, freely pivoted at its centre of mass.



Explain what is meant by the centre of mass.

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(1)

(c) A 1.0 N weight is placed on the ruler 0.30 m from the middle of the ruler towards A.

(i) Explain which way the pivot must be moved in order for equilibrium to be restored.

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(ii) Calculate the distance the pivot needs to be moved to restore equilibrium when the weight of the ruler is 0.50 N.

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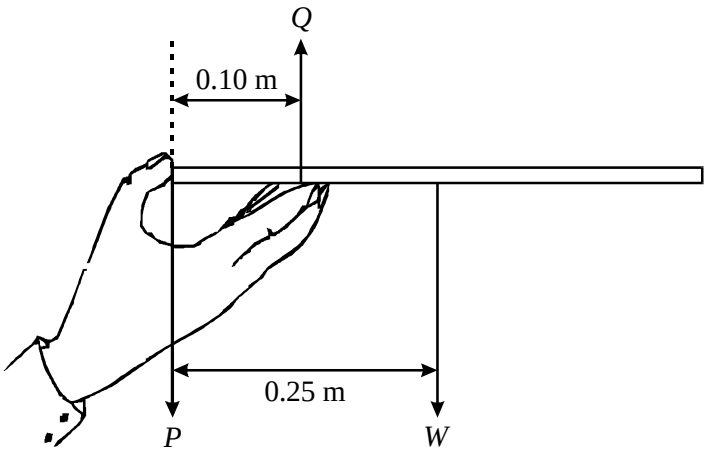
(5)
(Total 8 marks)

7. A waiter holds a tray horizontally in one hand between fingers and thumb as shown in the diagram.



P, *Q* and *W* are the three forces acting on the tray.

(a) (i) State **two** relationships between the forces that must be satisfied if the tray is to remain horizontal and in equilibrium.

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(ii) If the mass of the tray is 0.12 kg, calculate the magnitude of the force *W*.

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(iii) Calculate the magnitudes of forces *P* and *Q*.

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(6)

(b) The waiter places a glass on the tray. State and explain where the glass should be positioned on the tray if the force, *P*, is to have the same value as in part (a).

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(2)
(Total 8 marks)

8. (a) State the principle of moments.

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(3)

(b) (i) Draw a labelled diagram of the apparatus you would use to verify the principle of moments.

(ii) Describe the procedure that would be used and state what measurements are taken.

You may be awarded marks for the quality of written communication in your answer.

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(iii) Explain how the results would be used to verify the principle of moments.

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(7)
(Total 10 marks)