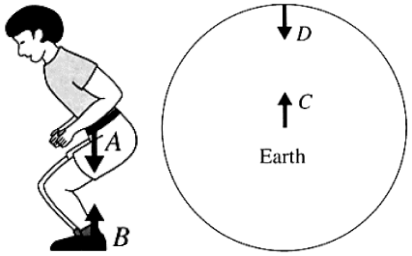
Forces and Equilibrium

1.

A child is crouching at rest on the ground.
Opposite are the free-body force diagrams for the child and the Earth.

(a) Copy out and complete the table describing forces A, B and C. [4 marks]

Force	Description of force	Body which exerts force	Body the force acts on
A	Gravitational	Earth	Child
B			
C			



(b) All the forces A, B, C and D are of equal magnitude.

Why are forces A and B equal in magnitude? [2 marks]

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(c) Why must forces B and D be equal in magnitude? [2 marks]

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(d) The child now jumps vertically upwards. With reference to the forces shown, explain what he must do to jump, and why he moves upwards. [3 marks]

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2.

A child sits on a swing and is pulled by a horizontal force **P** so that the chains make an angle with the vertical of 35°. Fig. 2.1 shows the forces acting in this position.

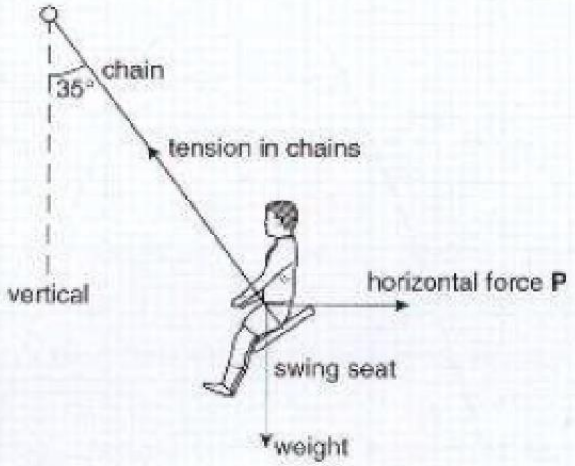

Fig. 2.1

The combined mass of the child and swing seat is 28 kg.

(a) Calculate the combined weight of the child and swing seat.

weight = ... N [2]

(b) When the child is held in equilibrium at the position shown in Fig. 2.1, work out,

(i) the tension in the chains

tension = …… N [3]

(ii) the size of the horizontal force, P

P =……N [3]

3.

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

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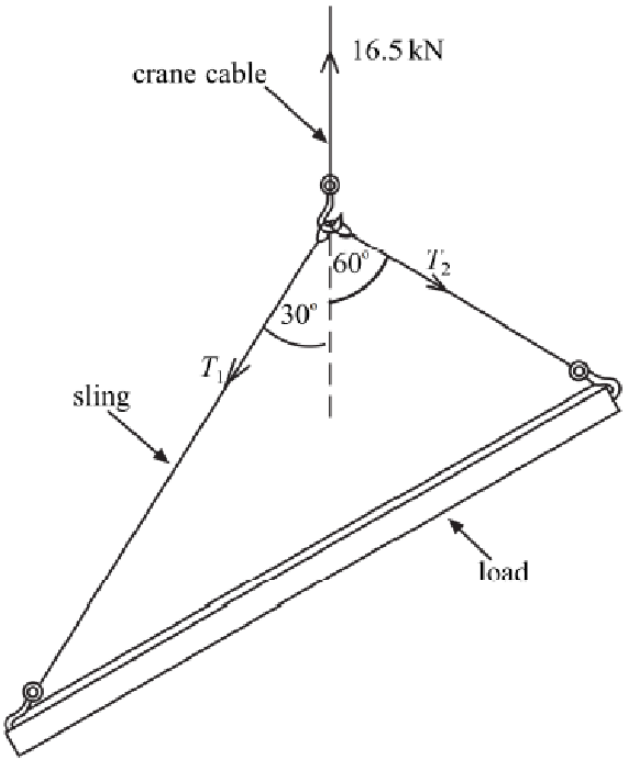
(1 mark)

(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.

(There is more space on page 5 to answer this question)

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T_1 = ...

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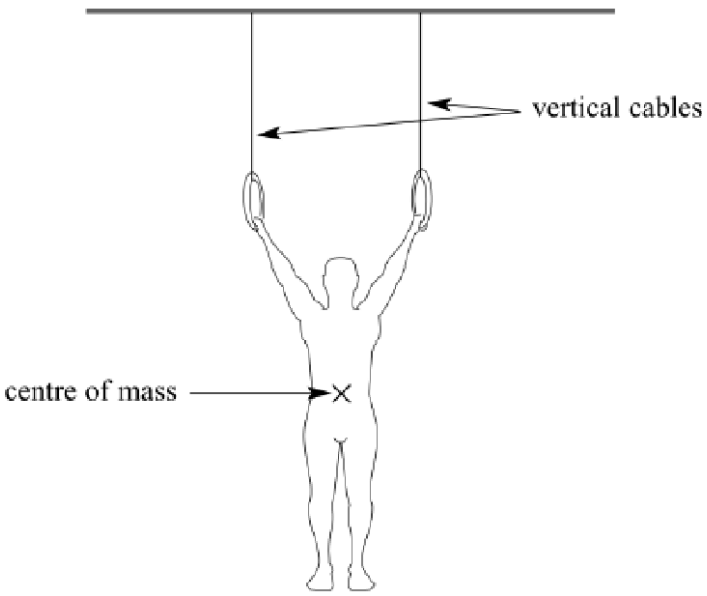
T_2 = ...

(4 marks)

4.

The diagram shows a gymnast of weight 720 N hanging centrally from two rings, each attached to cables which hang vertically.



(a) State the tension in each cable.

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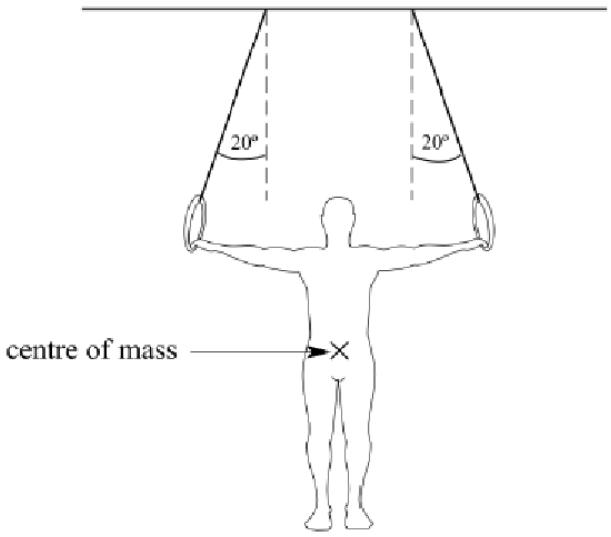
(1 mark)

(b) The diagram shows the gymnast after he has raised his body so that his centre of mass moves through a vertical distance of 0.60 m.



Calculate

(i) the increase in gravitational potential energy of the gymnast,

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(ii) the tension in each cable.

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(3 marks)

(c) The gymnast now raises his legs so that they become horizontal,without raising the rest of his body. State and explain whether his gravitational potential energy is changed by this manoeuvre.

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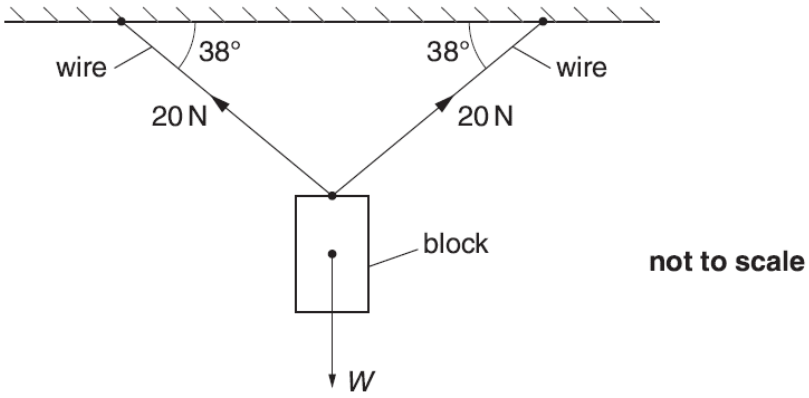
(2 marks)

5.

Fig. 5.2 shows a metal block held in equilibrium by two wires.



not to scale

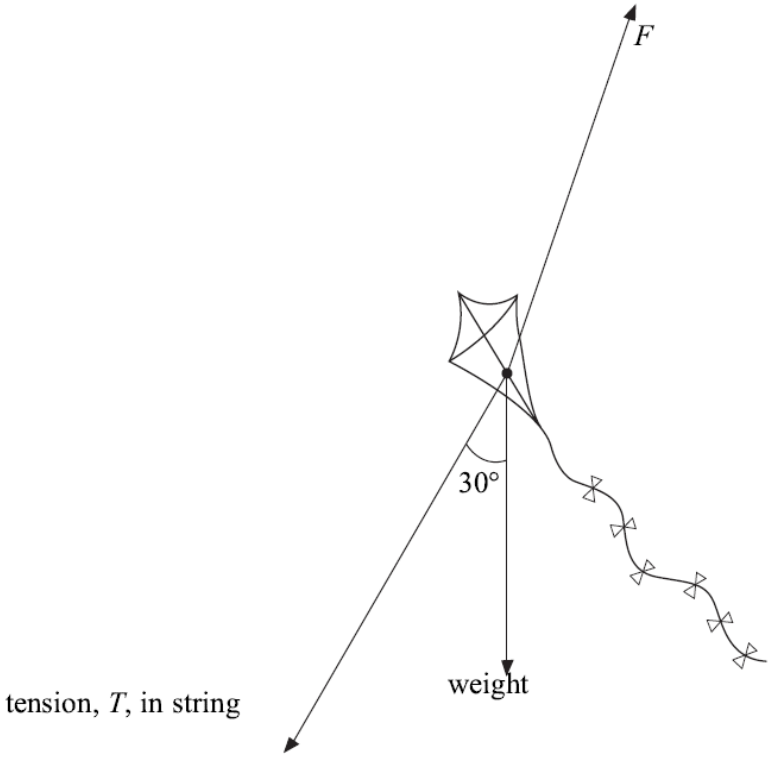
Fig. 5.2

The tension in each wire is 20 N.

Show that the weight *W* of the metal block is about 25 N.

6.

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

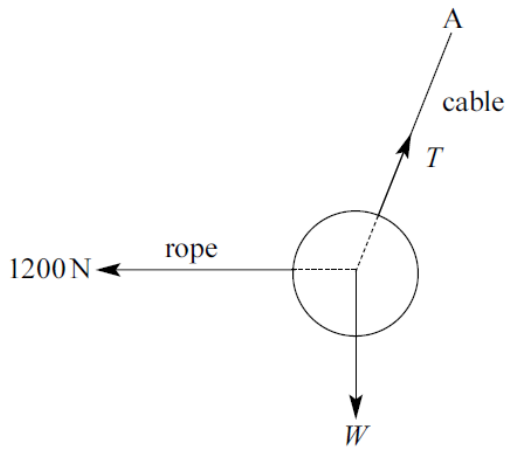


The weight of the kite is 2.5 N and the tension on the string is 25 N.

Work out the magnitude and direction of the force F exerted by the air on the kite.

7.

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.



The ball is in equilibrium in the position shown in the diagram.

Work out the magnitude of the tension and the angle the cable makes with the vertical in the position shown above.