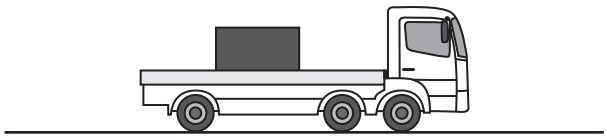
1 (a) A lorry gradually accelerates from rest. There is a box of mass 200 kg on the back of the lorry. The box is not tied to the lorry.



(i) The lorry accelerates from rest to a speed of 15 m s^{-1} over a distance of 39 m.

Show that the acceleration of the lorry is about 3 m s^{-2}.

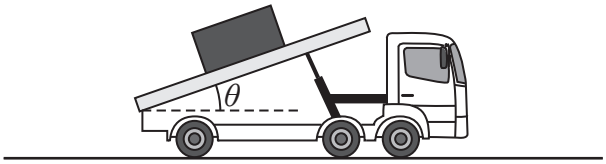
(2)

(ii) The maximum frictional force between the lorry and the box is 630 N.

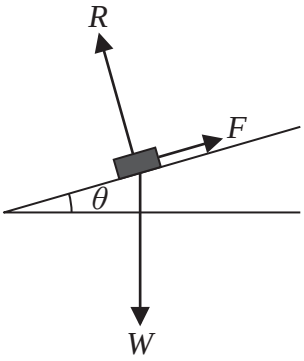
Explain why this limits the maximum acceleration that the lorry can have without the box falling off. Your answer should include a calculation.

(3)

(b) Once the lorry has reached its destination, the back of the lorry is tilted at an angle θ to the horizontal.



Three forces act on the box: the weight W, the normal contact force R and the frictional force F.



(i) State expressions for the components of the weight of the box parallel to the back of the lorry and perpendicular to the back of the lorry.

(2)

W_{parallel} =

$W_{\text{perpendicular}}$ =

(ii) The angle θ is increased until the box is just about to slide.

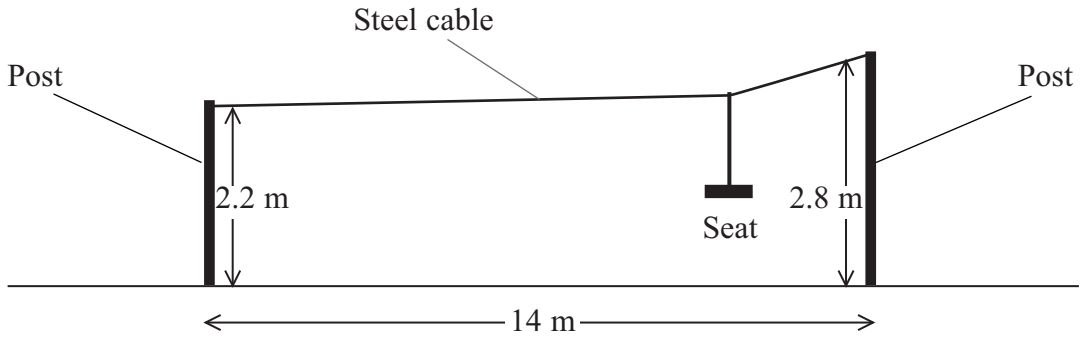
Given that $F = 0.32R$, calculate the value of θ at which the box is just about to slide.

(4)

θ =

(Total for Question = 11 marks)

2 A playground ride consists of a steel cable running at an angle between two posts of unequal height as shown in the diagram.



A child sits on the seat which moves on runners along the cable from the high end to the lower end.

(a) (i) Show that her maximum possible speed when she arrives at the lower post is about 3 m s ^{1}.

(4)

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(ii) State an assumption that you have made.

(1)

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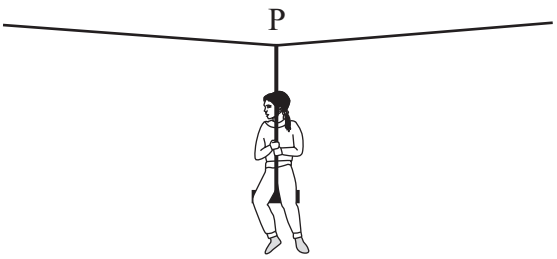
(b) The diagram below shows the child at a point P where both sides of the cable make an angle of 2° to the horizontal.



(i) Add labelled arrows to the diagram to show the forces acting on the cable at the point P.

(2)

(ii) The total mass of the child and seat is 40 kg.

Show that the tension in the cable is about 6000 N.

(3)

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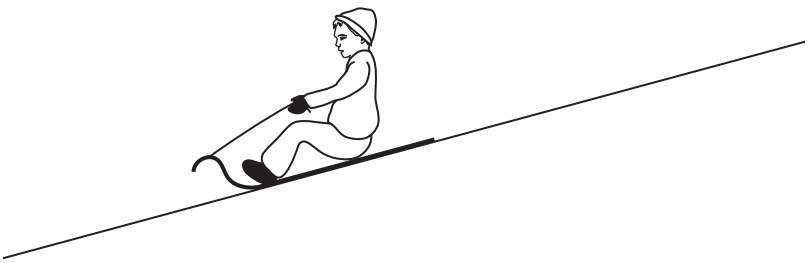
(Total for Question 10 marks)

3 (a) A child is going down a snowy hill on a sledge.



Complete, in the space below, a free-body force diagram for the child and sledge. Treat the child and sledge as a single body object.

(2)

(b) The child and sledge are pulled across level ground by an adult.

(i) They are pulled 11 m from rest in 4.9 s.

Show that the average acceleration is about 1 m s ^{2}.

(2)

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(ii) The child and sledge have a combined mass of 40 kg.

Calculate the average resultant force on the child and sledge.

(2)

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(c) The force applied by the adult is 200 N at an angle of 20° to the horizontal.

(i) Calculate the average resistive force acting while the sledge is being pulled.

(2)

Average resistive force .....

(ii) Calculate the average power developed by the adult in pulling the sledge 11 m.

(3)

Average power .....

(Total for Question 11 marks)

4 (a) What is meant by Newton's first law of motion?

(2)

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(b) Newton's third law identifies pairs of forces.

(i) State **two** ways in which the forces in a pair are identical.

(2)

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(ii) State **two** ways in which the forces in a pair differ.

(2)

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(iii) One of the forces acting on a car can be described as follows:

'The Earth exerts a downward gravitational force of 12 000 N on the car'.

Describe its Newton's third law pair force.

(2)

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(Total for Question = 8 marks)