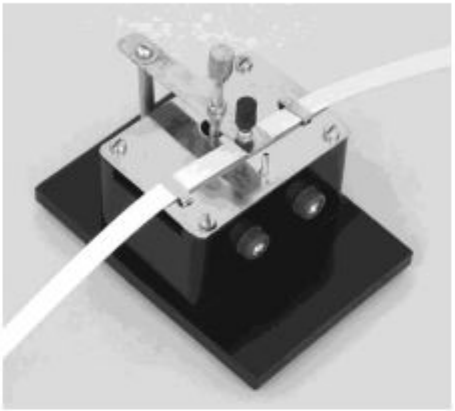
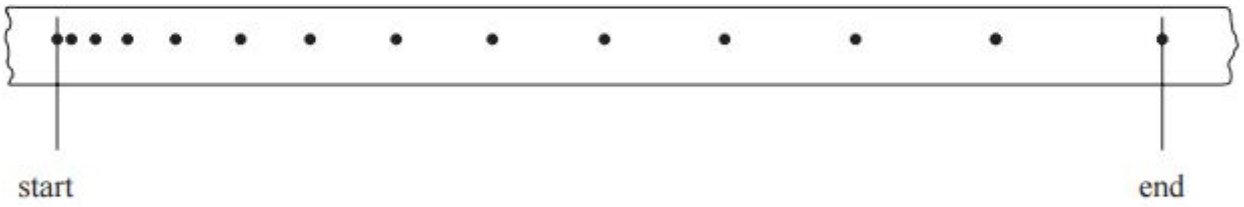
1 A trolley moves down a ramp from rest. Attached to the trolley is a strip of paper which is pulled through a ticker tape timer. The ticker tape timer makes 50 dots each second on the strip of paper.



The strip of paper is shown below. The start and the end of the journey are indicated.



(a) (i) Using measurements from the tape show that the final velocity of the trolley is about 1 m s^{-1}

(2)

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(ii) Hence calculate the average acceleration of the trolley.

(2)

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Average acceleration = ...

(b) Using a ticker tape timer is one method of measuring the speed of a moving object in a laboratory. Another method is to use a light gate with a data logger and computer.

Suggest an advantage of using the light gate method rather than using a ticker tape timer.

(1)

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(Total for Question = 5 marks)

2 There has been a proposal to build a train tunnel underneath the Atlantic Ocean from England to America. The suggestion is that in the future the trip of 5000 km could take as little as one hour.

Assume that half the time is spent accelerating uniformly and the other half is spent decelerating uniformly with the same magnitude as the acceleration.

(a) Show that the acceleration would be about 2 m s^{-2}.

(2)

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(b) Calculate the maximum speed.

(2)

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Speed = ...

(c) Calculate the resultant force required to decelerate the train.

mass of train = 4.5×10^5 kg

(2)

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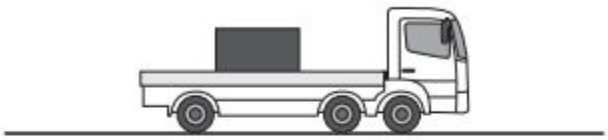
Force = ...

(Total for Question = 6 marks)

3 (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)

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(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)

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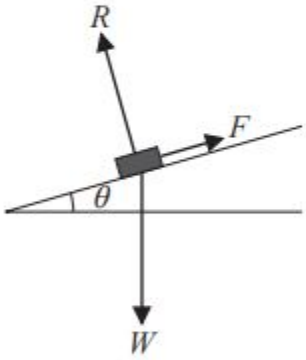
(b) Once the lorry has reached its destination, the back of the lorry is tilted at an angle θ to the horizontal.

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)

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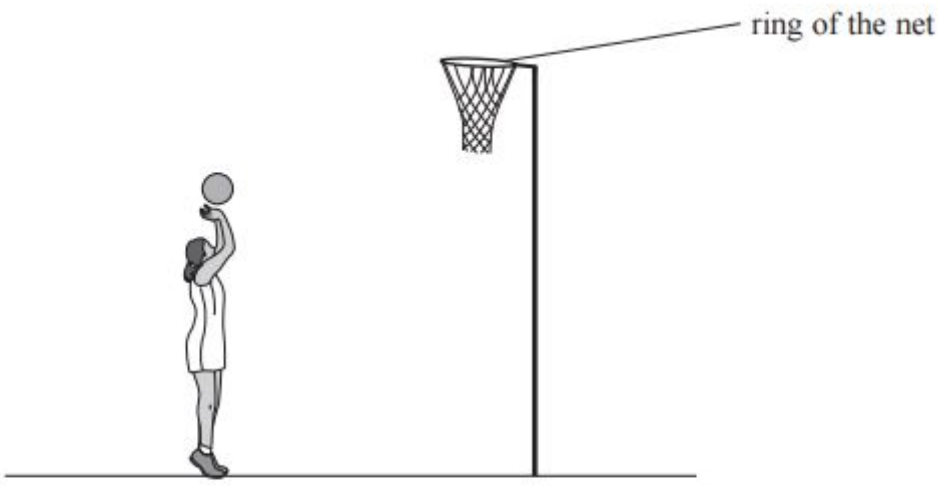
θ = ...

(Total for Question = 11 marks)

4 In a game of netball, a goal is scored when the ball passes through the ring at the top of the net.

(a) On the diagram below draw the path the ball should take if a goal is to be scored.

(1)



(b) A student is given the following information for a particular attempt at a goal.

initial velocity of ball on release = 4.5 m s^{-1}
release angle of ball = 60° from the horizontal
horizontal distance from centre of ball to centre of ring = 1.5 m

(i) Show that the time taken to travel the horizontal distance of 1.5 m is about 0.7 s.

(3)

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(ii) Calculate the vertical displacement of the ball when it has travelled a horizontal distance of 1.5 m and hence comment on whether a goal will be scored.

vertical distance of ring from release point = 0.70 m

(4)

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Vertical displacement = ...

Comment .....

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(iii) Explain how air resistance would have affected the calculation in (b)(i).

(2)

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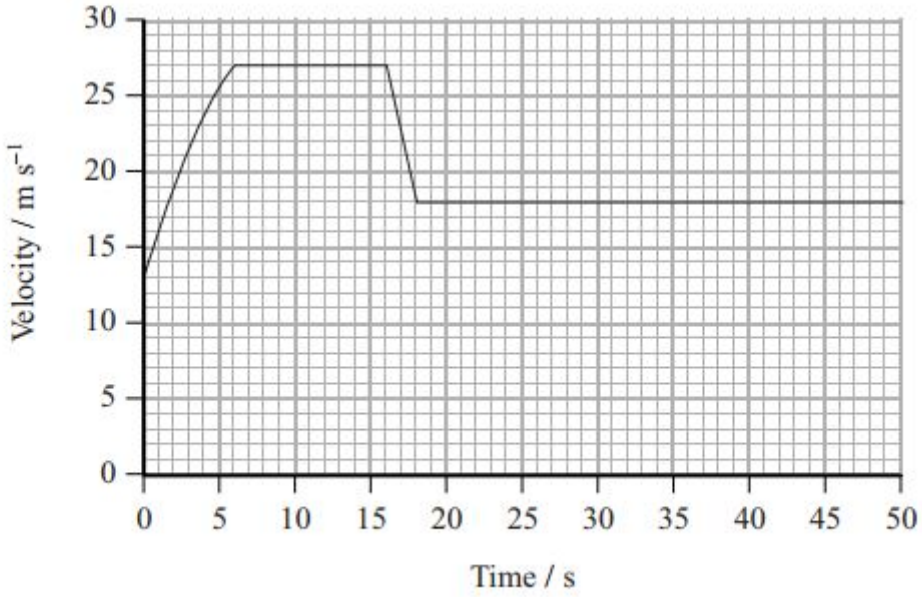
(Total for Question = 10 marks)

5 The speeds of cars travelling through roadworks on major roads are often monitored by 'average speed check' cameras. This is done by timing a car between two cameras a large distance apart.

The graph shows how the velocity of a car varies with time as it passes between two average speed check cameras. The car passes the cameras at time $t = 0$ s and $t = 50$ s.



A constant driving force is applied to the car for the first 6 s. At time $t = 16$ s the driver realises the car is travelling too fast for the 22 m s^{-1} speed limit (50 miles per hour) and applies the brakes until time $t = 18$ s.

(a) Calculate the acceleration at time $t = 3$ s.

(3)

Acceleration = ...

(b) Describe and explain the shape of the line in the first 6 s.

(4)

(c) Describe the resultant force on the car between times $t = 6$ s and $t = 16$ s.

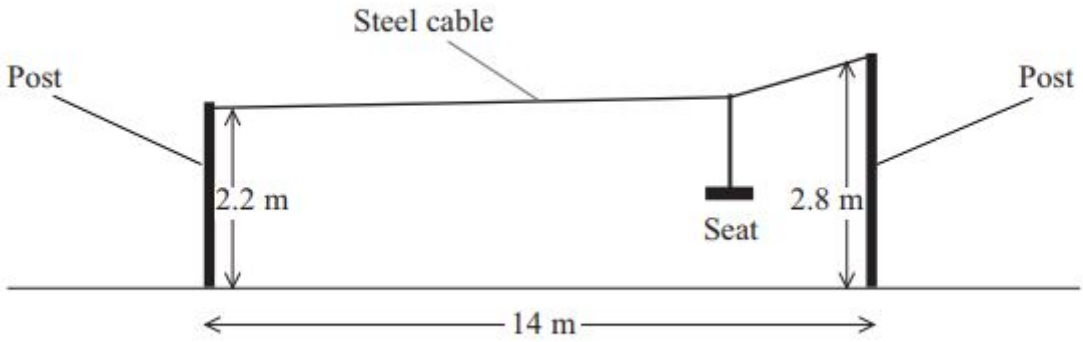
(1)

(d) Show that the average speed of the car does not exceed the average speed limit of 22 m s^{-1}.

(4)

(Total for Question = 12 marks)

6 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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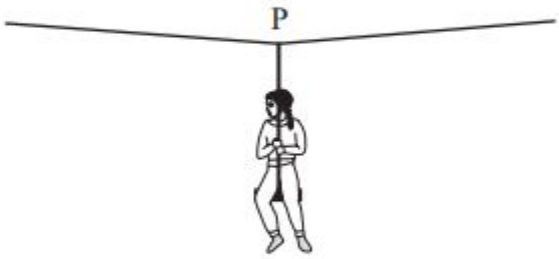
(b) The diagram below shows the child at a point P where both sides of the cable make an angle of 2° to the horizontal.



(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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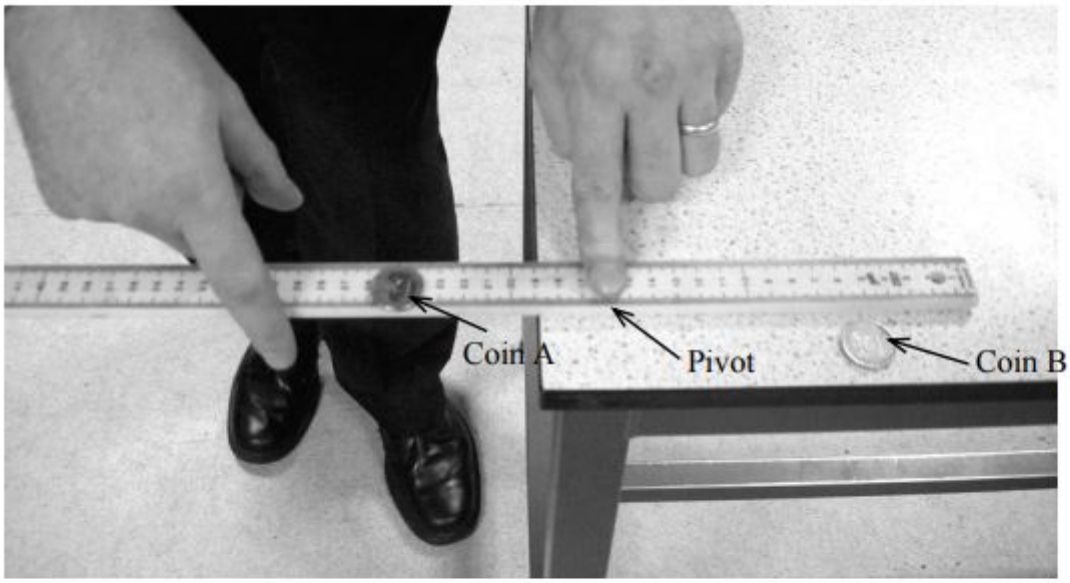
(Total for Question = 10 marks)

7 The photograph shows a physics teacher carrying out a demonstration related to vertical motion.



A coin, A, is placed on top of the smooth ruler and another coin, B, is placed on the table.
One hand is acting as a pivot. The other hand gives the ruler a sharp horizontal tap.

Coin A falls vertically to the ground while coin B is pushed horizontally off the table.
Both coins are heard to strike the floor at the same instant.

(a) Use Newton's first law to explain why the coin A has no horizontal motion.

(2)

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(b) Explain how this demonstration shows the independence of vertical and horizontal motion.

(2)

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(c) The table is 0.85 m high.

Show that the coin on the ruler strikes the ground with a speed of about 4 m s^{-1}.

(2)

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(d) After 0.42 s the second coin lands at a horizontal distance of 1.1 m from the table.

Calculate the velocity at which the coin strikes the ground.

(5)

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Magnitude of velocity = ...

Angle of velocity to horizontal = ...

(Total for Question = 11 marks)