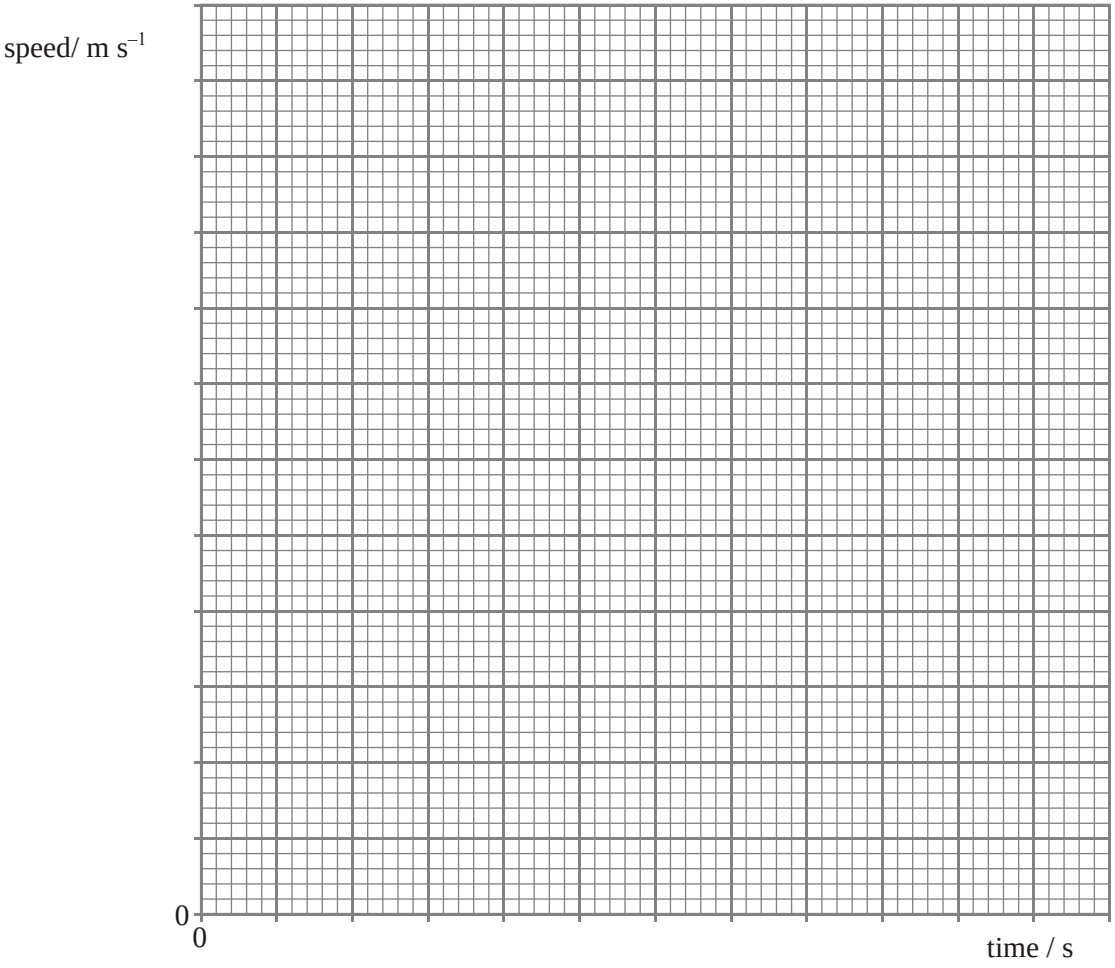
1. A car accelerates from rest to a speed of 26 m s^{-1}. The table shows how the speed of the car varies over the first 30 seconds of motion.

time/ s	0	5.0	10.0	15.0	20.0	25.0	30.0
speed/ m s^{-1}	0	16.5	22.5	24.5	25.5	26.0	26.0

(a) Draw a graph of speed against time on the grid provided.



(3)

(b) Calculate the average acceleration of the car over the first 25 s.

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(2)

(c) Use your graph to estimate the distance travelled by the car in the first 25 s.

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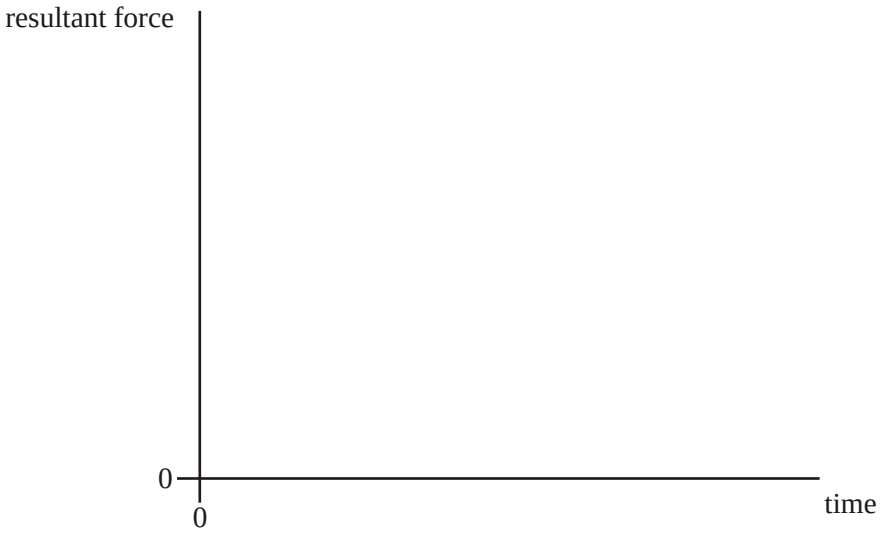
(2)

(d) Using the axes below, sketch a graph to show how the resultant force acting on the car varies over the first 30 s of motion.



(2)

(e) Explain the shape of the graph you have sketched in part (d), with reference to the graph you plotted in part (a).

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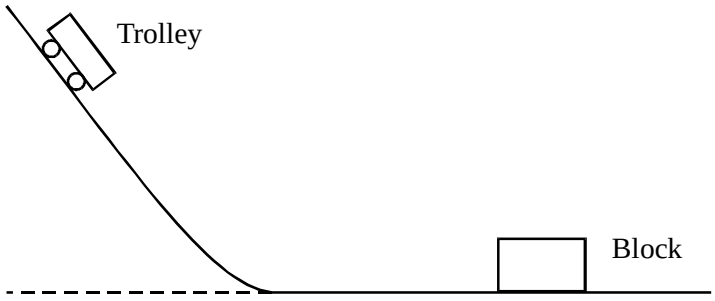
(2)

(Total 11 marks)

2. The diagram represents an experiment that can be used to investigate stopping distances for a moving trolley.



The trolley is placed on the raised section of the track. When released it moves down the track and then travels along the horizontal section before colliding with the block. The trolley and block join and move together after the collision. The distance they move is measured.

(a) State the main energy changes taking place

(i) as the trolley descends,

.....

(ii) after the collision, as the trolley and block move together.

.....

(2)

(b) Describe how the speed of the trolley, just before it collides with the block may be measured experimentally.

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

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(3)

(c) State and explain how the speed of the trolley, prior to impact could be varied.

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(2)
(Total 7 marks)

3. (a) Explain why a raindrop falling vertically through still air reaches a constant velocity. You may be awarded marks for the quality of written communication in your answer.

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(4)

(b) A raindrop falls at a constant vertical velocity of 1.8 m s^{-1} in still air. The mass of the raindrop is 7.2×10^{-9} kg.

Calculate

(i) the kinetic energy of the raindrop,

.....

.....

(ii) the work done on the raindrop as it falls through a vertical distance of 4.5 m.

.....

.....

(4)

(c) The raindrop in part (b) now falls through air in which a horizontal wind is blowing. If the velocity of the wind is 1.4 m s^{-1}, use a scale diagram or calculation to determine the magnitude and direction of the resultant velocity of the raindrop.

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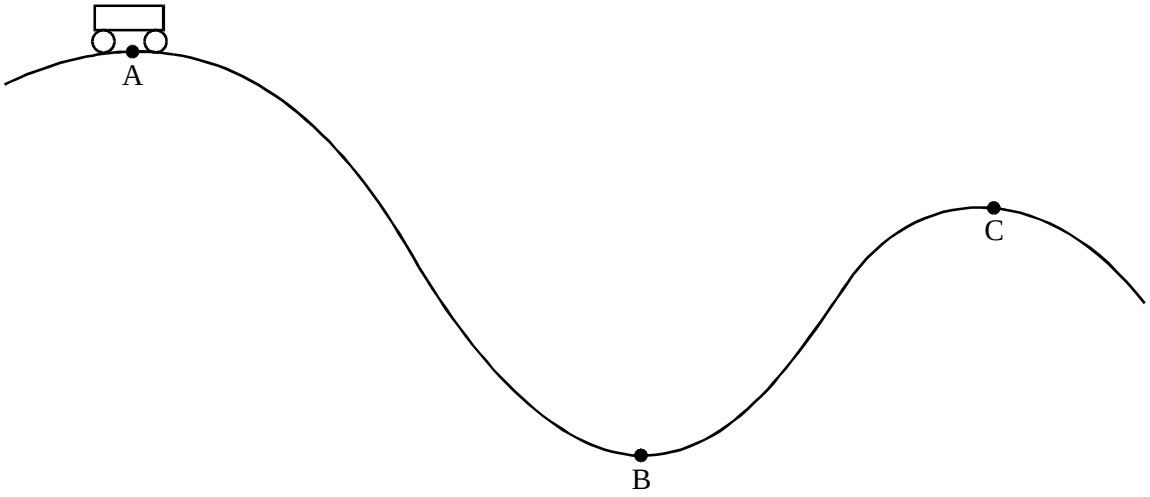
(3)

(Total 11 marks)

4. The figure shows the track of a funfair ride.



Carriages are pulled up to the highest point, A, of the ride and then released so that they follow the path ABC.

(a) Point A is 18 m above the ground and point C is 12 m above the ground. Show that the maximum possible speed of the carriage at C is 11 m s^{-1}.

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(3)

(b) The actual speed at C is less than 11 m s^{-1}. Describe the energy changes that take place as the carriage moves from A to B to C.

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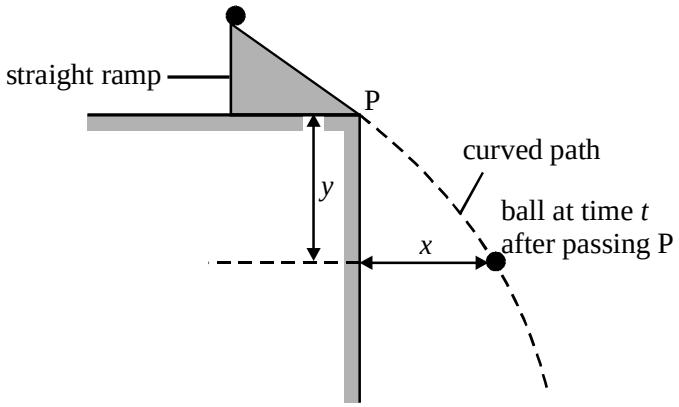
(4)
(Total 7 marks)

5. While investigating projectile motion, a student used stroboscopic photography to determine the position of a steel ball at regular intervals as it fell under gravity. With the stroboscope flashing 20 times per second, the ball was released from rest at the top of an inclined track, and left the foot of the track at P, as shown in the diagram below.



For each of the images on the photograph, the student calculated the horizontal distance, *x*, and the vertical distance, *y*, covered by the ball at time *t* after passing P. Both distances were measured from point P. He recorded his results for the distances *x* and *y* in the table.

image	*x*/cm	*y*/cm	*t*/s	(y/t)/cm s^{-1}
1	11.6	9.3	0.05	
2	22.0	21.0	0.10	
3	32.4	35.0	0.15	
4	44.2	51.8	0.20	
5	54.8	71.0	0.25	
6	66.0	92.2	0.30	

(a) Using two sets of measurements from the table, calculate the horizontal component of velocity of the ball. Give a reason for your choice of measurements.

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.....

(2)

(b) The student worked out that the variables y and t in the experiment could be represented by

$$\frac{y}{t} = u + kt$$

where u and k are constants.

(i) Complete the table above.

(ii) Use the data in the table to plot a suitable graph to confirm the equation.

(Allow one sheet pf graph paper)

(iii) Use your graph to find the values of u and k.

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.....

.....

(9)

(c) State the physical significance of

u .....

.....

k .....

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(2)

(d) Calculate the magnitude of the velocity of the ball at point P.

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(2)
(Total 15 marks)

6. Athlete A, competing in a 100 m race, crosses the finish line in a time of 10.2 s. At the start, the athlete accelerates uniformly to a top speed in 2.0 s and then remains at a constant speed for the remainder of the race.

(a) Calculate

(i) the average speed of the athlete over the full distance,

.....

.....

(ii) the maximum speed of the athlete if the acceleration were 5.4 m s^{-2},

.....

.....

(iii) the distance travelled by the athlete whilst accelerating.

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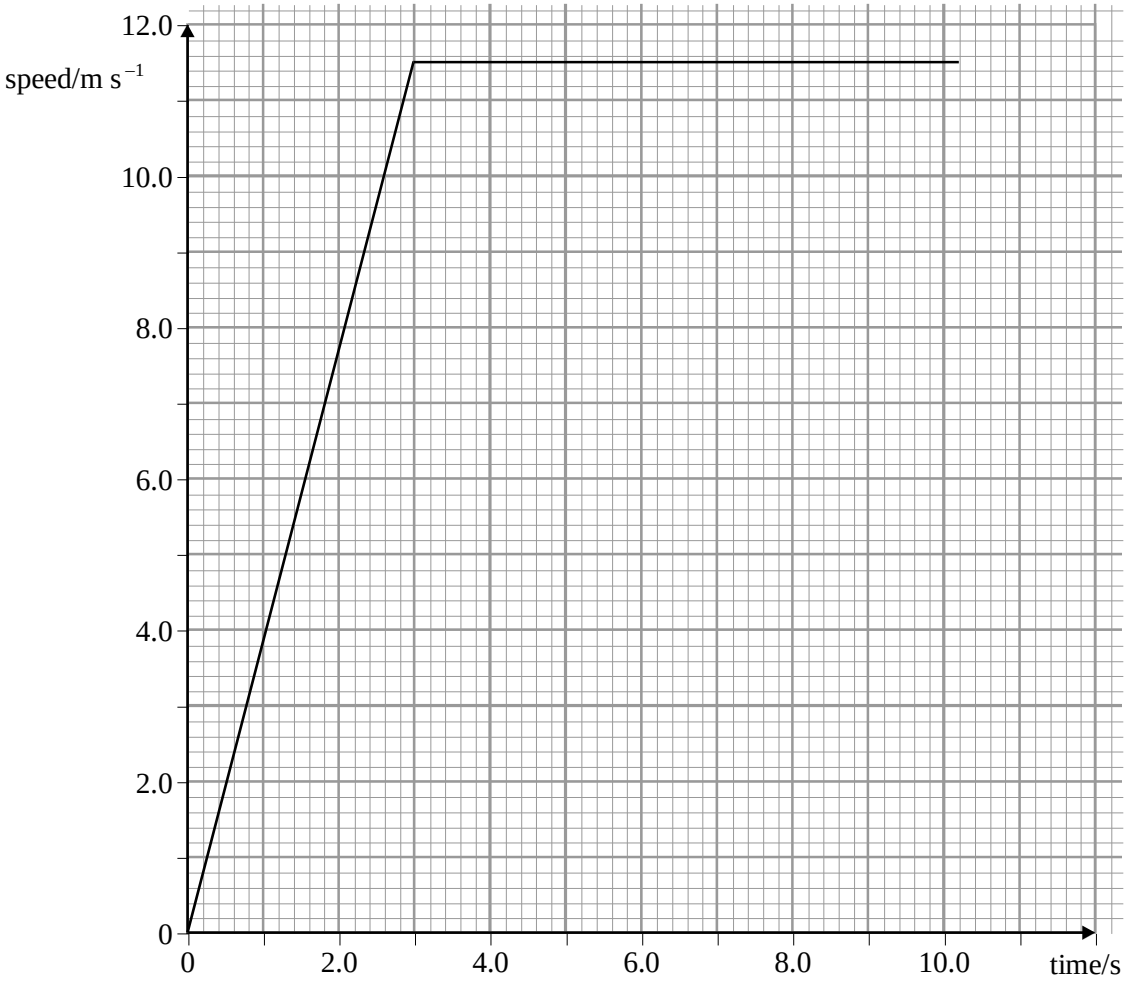
(4)

(b) The graph is a speed time graph for athlete B in the same race.



Using the **same** axes, draw a speed time graph for athlete A.

(3)

(c) Some time after the start of the race the two athletes are running at the same speed. Use your graph to determine

(i) the time at which this occurs,

.....

(ii) the distance covered by the athletes up to this time,

Athlete A: .....

.....

Athlete B: .....

.....

(iii) how far apart the athletes are at this time.

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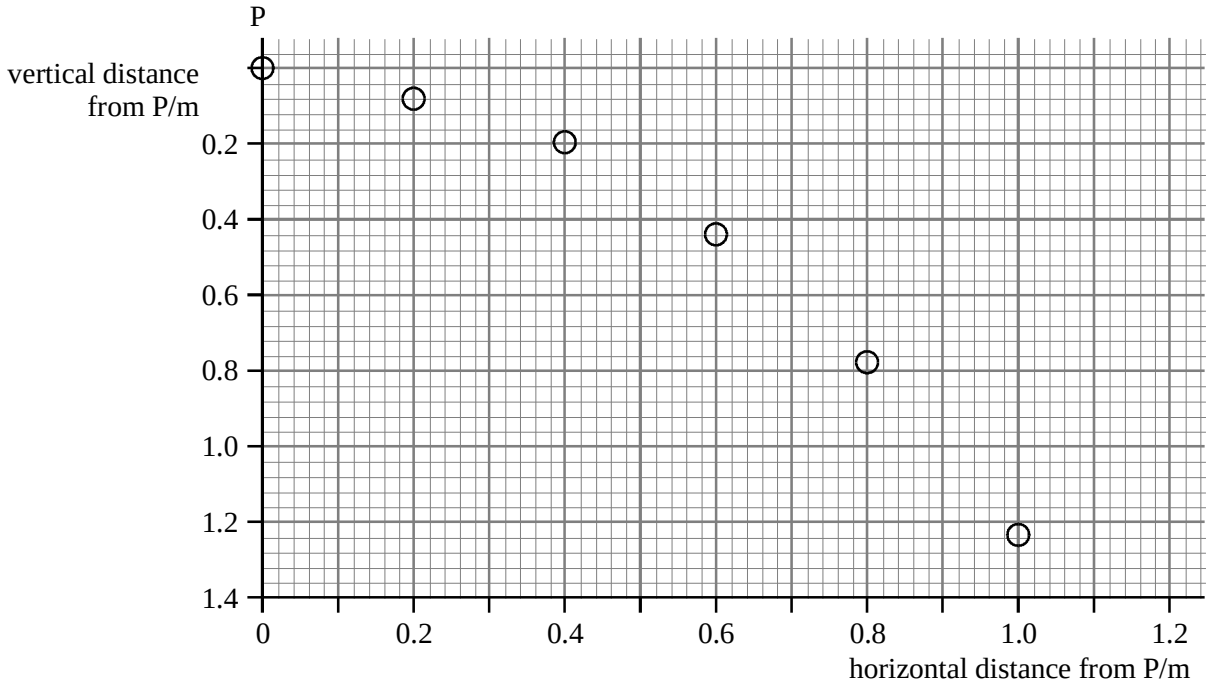
(4)
(Total 11 marks)

7. The graph shows how the position of a steel ball which has been projected horizontally from P changes with time. The position of the ball is shown at constant time intervals.



(a) Explain how the horizontal motion of the ball shows that air resistance is negligible.

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(2)

(b) Explain the vertical motion of the ball.

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(2)

(c) If air resistance were not negligible, describe how this would affect

(i) the horizontal motion of the ball,

.....

.....

(ii) the vertical motion of the ball.

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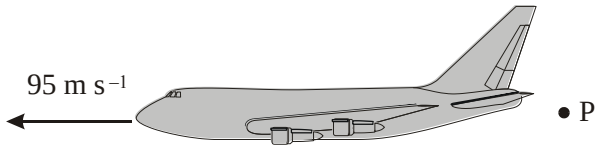
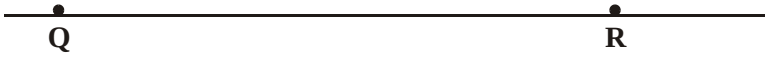
(3)
(Total 7 marks)

8. The aeroplane shown in the diagram below is travelling horizontally at 95 m s^{-1}. It has to drop a crate of emergency supplies.
The air resistance acting on the crate may be neglected.





(a) (i) The crate is released from the aircraft at point **P** and lands at point **Q**. Sketch the path followed by the crate between **P** and **Q** as seen from the ground.

(ii) Explain why the horizontal component of the crate's velocity remains constant while it is moving through the air.

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(3)

(b) (i) To avoid damage to the crate, the maximum vertical component of the crate's velocity on landing should be 32 m s^{-1}. Show that the maximum height from which the crate can be dropped is approximately 52 m.

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(ii) Calculate the time taken for the crate to reach the ground if the crate is dropped from a height of 52 m.

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(iii) If **R** is a point on the ground directly below **P**, calculate the horizontal distance **QR**.

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(6)

(c) In practice air resistance is **not** negligible. State and explain the effect this has on the maximum height from which the crate can be dropped.

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(2)

(Total 11 marks)