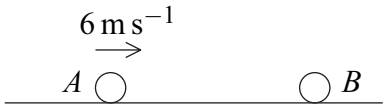
NOTICE TO CUSTOMER:

The sale of this product is intended for use of the original purchaser only and for use only on a single computer system. Duplicating, selling, or otherwise distributing this product is a violation of the law ; your license of the product will be terminated at any moment if you are selling or distributing the products.

Answer **all** questions.

1 A particle A moves across a smooth horizontal surface in a straight line. The particle A has mass 2 kg and speed $6\,\text{m s}^{-1}$. A particle B, which has mass 3 kg, is at rest on the surface. The particle A collides with the particle B.



(a) If, after the collision, A is at rest and B moves away from A, find the speed of B. *(3 marks)*

(b) If, after the collision, A and B move away from each other with speeds $v\,\text{m s}^{-1}$ and $4v\,\text{m s}^{-1}$ respectively, as shown in the diagram below, find the value of v.

(3 marks)

2 A girl throws a ball vertically upwards with a speed of $10.5\,\text{m s}^{-1}$ and subsequently catches it at the same point from which it was thrown.

Find:

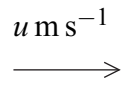
(a) the greatest height that the ball reaches above the point from which it is thrown; *(2 marks)*

(b) (i) the time that the ball takes to reach the greatest height; *(2 marks)*

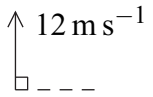
(ii) the time between the ball being thrown and being caught. *(1 mark)*

3 Water flows in a constant direction at a constant speed of $u\,\text{m s}^{-1}$. A boat travels in the water at a speed of $12\,\text{m s}^{-1}$ relative to the water.

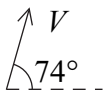
(a) The direction in which the boat travels relative to the water is perpendicular to the direction of motion of the water. The resultant velocity of the boat is $V\,\text{m s}^{-1}$ at an angle of 74° to the direction of motion of the water, as shown in the diagram.



Velocity of the water



Velocity of the boat relative to the water

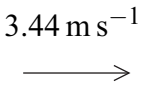


Resultant velocity of the boat

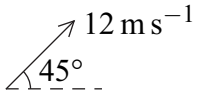
(i) Find V. *(2 marks)*

(ii) Show that $u = 3.44$, correct to three significant figures. *(3 marks)*

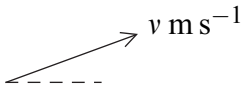
(b) The boat changes course so that it travels relative to the water at an angle of 45° to the direction of motion of the water. The resultant velocity of the boat is now of magnitude $v\,\text{m s}^{-1}$. The velocity of the water is unchanged, as shown in the diagram below.



Velocity of the water



Velocity of the boat relative to the water

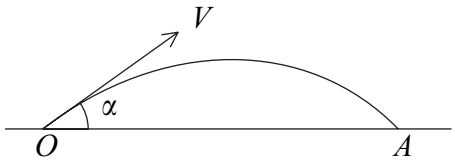


Resultant velocity of the boat

Find the value of v. *(4 marks)*

Turn over for the next question

4 A golf ball is projected from a point O with initial velocity V at an angle α to the horizontal. The ball first hits the ground at a point A which is at the same horizontal level as O, as shown in the diagram.



It is given that $V\cos\alpha = 6u$ and $V\sin\alpha = 2.5u$.

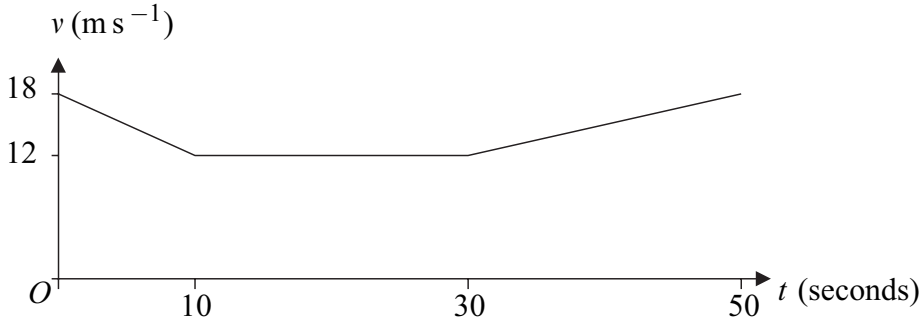
(a) Show that the time taken for the ball to travel from O to A is $\dfrac{5u}{g}$. *(4 marks)*

(b) Find, in terms of g and u, the distance OA. *(2 marks)*

(c) Find V in terms of u. *(2 marks)*

(d) State, in terms of u, the least speed of the ball during its flight from O to A. *(1 mark)*

5 The velocity–time graph below represents the three stages of the motion of a coach moving along a straight horizontal road. Initially the coach has velocity $18\,\text{m s}^{-1}$.



(a) During the first stage of the motion, the coach decelerates at a constant rate of $a\,\text{m s}^{-2}$ for 10 seconds until it reaches a velocity of $12\,\text{m s}^{-1}$.

(i) Find the value of a. *(2 marks)*

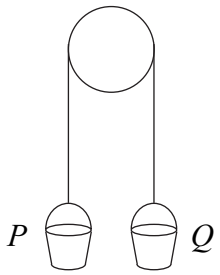
(ii) Find the distance that the coach travels during the 10 seconds. *(2 marks)*

(b) During the second stage of the motion, the coach travels for 20 seconds with constant velocity $12\,\text{m s}^{-1}$. Find the distance that the coach travels during these 20 seconds. *(1 mark)*

(c) During the third stage of the motion, the coach travels with constant acceleration, reaching a velocity of $18\,\text{m s}^{-1}$ after a further 20 seconds.

Find the average speed of the coach during the 50 seconds of the motion. *(4 marks)*

6 A builder ties two identical buckets, P and Q, to the ends of a light inextensible rope. He hangs the rope over a smooth beam so that the buckets hang in equilibrium, as shown in the diagram.



The buckets are each of mass 0.6 kg.

(a) (i) State the magnitude of the tension in the rope. *(1 mark)*

(ii) State the magnitude and direction of the force exerted on the beam by the rope. *(2 marks)*

(b) The bucket Q is held at rest while a stone, of mass 0.2 kg, is placed inside it. The system is then released from rest and, in the subsequent motion, bucket Q moves vertically downwards with the stone inside.

(i) By forming an equation of motion for each bucket, show that the magnitude of the tension in the rope during the motion is 6.72 newtons, correct to three significant figures. *(6 marks)*

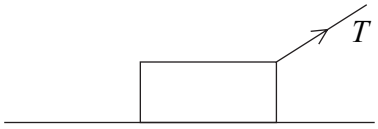
(ii) State the magnitude of the force exerted on the beam by the rope while the motion takes place. *(1 mark)*

Turn over for the next question

7 A crate is being pulled at constant speed across rough horizontal ground by a rope.

The crate is of weight 100 newtons and the frictional force between the crate and the ground is of magnitude 30 newtons.

The tension in the rope is of magnitude T newtons.



(a) Draw and label a diagram to show all the forces acting on the crate. *(1 mark)*

(b) The coefficient of friction between the crate and the ground is 0.5 . Show that the normal reaction force between the crate and the ground is 60 newtons. *(2 marks)*

(c) Explain why the horizontal component of the tension in the rope is 30 newtons. *(2 marks)*

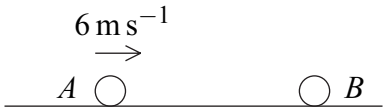
(d) Find the value of T. *(4 marks)*

(e) Find the angle that the rope makes with the horizontal. *(3 marks)*

END OF QUESTIONS

Answer **all** questions.

1 A particle A moves across a smooth horizontal surface in a straight line. The particle A has mass 2 kg and speed $6\,\text{m s}^{-1}$. A particle B, which has mass 3 kg, is at rest on the surface. The particle A collides with the particle B.



(a) If, after the collision, A is at rest and B moves away from A, find the speed of B. *(3 marks)*

(b) If, after the collision, A and B move away from each other with speeds $v\,\text{m s}^{-1}$ and $4v\,\text{m s}^{-1}$ respectively, as shown in the diagram below, find the value of v.

(3 marks)

2 A particle P moves with acceleration $(-3\mathbf{i} + 12\mathbf{j})\,\text{m s}^{-2}$. Initially the velocity of P is $4\mathbf{i}\,\text{m s}^{-1}$.

(a) Find the velocity of P at time t seconds. *(2 marks)*

(b) Find the speed of P when $t = 0.5$. *(3 marks)*

3 (a) A small stone is dropped from a height of 25 metres above the ground.

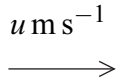
(i) Find the time taken for the stone to reach the ground. *(2 marks)*

(ii) Find the speed of the stone as it reaches the ground. *(2 marks)*

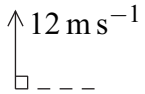
(b) A large package is dropped from the same height as the stone. Explain briefly why the time taken for the package to reach the ground is likely to be different from that for the stone. *(2 marks)*

4 Water flows in a constant direction at a constant speed of $u\,\text{m s}^{-1}$. A boat travels in the water at a speed of $12\,\text{m s}^{-1}$ relative to the water.

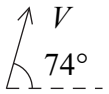
(a) The direction in which the boat travels relative to the water is perpendicular to the direction of motion of the water. The resultant velocity of the boat is $V\,\text{m s}^{-1}$ at an angle of 74° to the direction of motion of the water, as shown in the diagram.



Velocity of the water



Velocity of the boat relative to the water

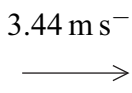


Resultant velocity of the boat

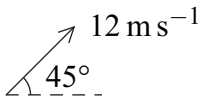
(i) Find V. *(2 marks)*

(ii) Show that $u = 3.44$, correct to three significant figures. *(3 marks)*

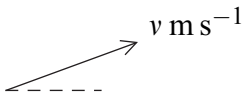
(b) The boat changes course so that it travels relative to the water at an angle of 45° to the direction of motion of the water. The resultant velocity of the boat is now of magnitude $v\,\text{m s}^{-1}$. The velocity of the water is unchanged, as shown in the diagram below.



Velocity of the water



Velocity of the boat relative to the water

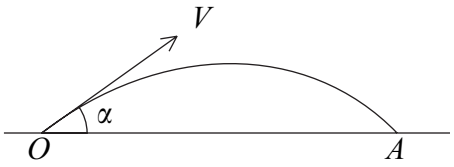


Resultant velocity of the boat

Find the value of v. *(4 marks)*

Turn over for the next question

5 A golf ball is projected from a point O with initial velocity V at an angle α to the horizontal. The ball first hits the ground at a point A which is at the same horizontal level as O, as shown in the diagram.



It is given that $V\cos\alpha = 6u$ and $V\sin\alpha = 2.5u$.

(a) Show that the time taken for the ball to travel from O to A is $\dfrac{5u}{g}$. *(4 marks)*

(b) Find, in terms of g and u, the distance OA. *(2 marks)*

(c) Find V, in terms of u. *(2 marks)*

(d) State, in terms of u, the least speed of the ball during its flight from O to A. *(1 mark)*

6 A van moves from rest on a straight horizontal road.

(a) In a simple model, the first 30 seconds of the motion are represented by three separate stages, each lasting 10 seconds and each with a constant acceleration.

During the first stage, the van accelerates from rest to a velocity of $4\,\text{m s}^{-1}$.

During the second stage, the van accelerates from $4\,\text{m s}^{-1}$ to $12\,\text{m s}^{-1}$.

During the third stage, the van accelerates from $12\,\text{m s}^{-1}$ to $16\,\text{m s}^{-1}$.

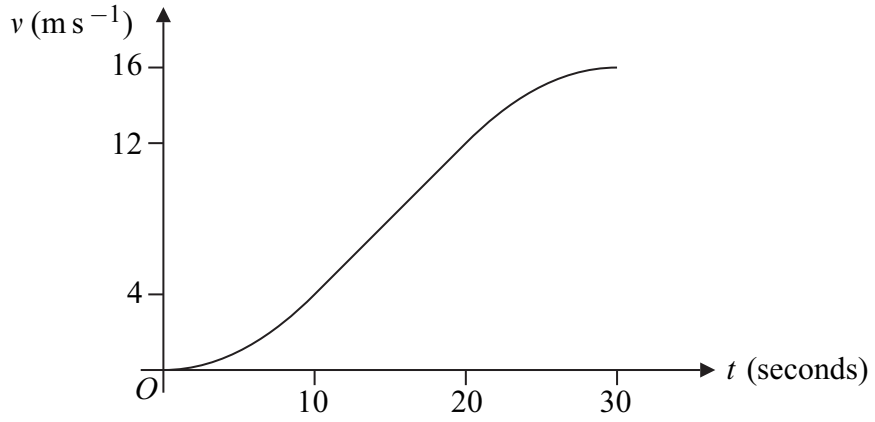
(i) Sketch a velocity–time graph to represent the motion of the van during the first 30 seconds of its motion. *(3 marks)*

(ii) Find the total distance that the van travels during the 30 seconds. *(4 marks)*

(iii) Find the average speed of the van during the 30 seconds. *(2 marks)*

(iv) Find the greatest acceleration of the van during the 30 seconds. *(2 marks)*

(b) In another model of the 30 seconds of the motion, the acceleration of the van is assumed to vary during the first and third stages of the motion, but to be constant during the second stage, as shown in the velocity–time graph below.

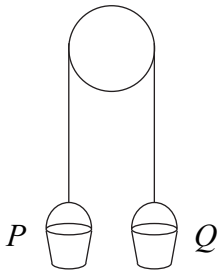


The velocity of the van takes the same values at the beginning and the end of each stage of the motion as in part (a).

(i) State, with a reason, whether the distance travelled by the van during the first 10 seconds of the motion in **this** model is greater or less than the distance travelled during the same time interval in the model in part (a). *(2 marks)*

(ii) Give one reason why **this** model represents the motion of the van more realistically than the model in part (a). *(1 mark)*

7 A builder ties two identical buckets, P and Q, to the ends of a light inextensible rope. He hangs the rope over a smooth beam so that the buckets hang in equilibrium, as shown in the diagram.



The buckets are each of mass 0.6 kg.

(a) (i) State the magnitude of the tension in the rope. *(1 mark)*

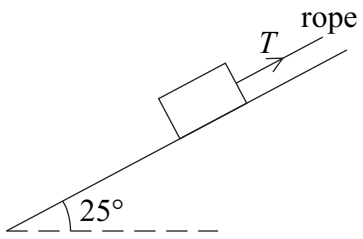
(ii) State the magnitude and direction of the force exerted on the beam by the rope. *(2 marks)*

(b) The bucket Q is held at rest while a stone, of mass 0.2 kg, is placed inside it. The system is then released from rest and, in the subsequent motion, bucket Q moves vertically downwards with the stone inside.

(i) By forming an equation of motion for each bucket, show that the magnitude of the tension in the rope during the motion is 6.72 newtons, correct to three significant figures. *(6 marks)*

(ii) State the magnitude of the force exerted on the beam by the rope while the motion takes place. *(1 mark)*

8 A rough slope is inclined at an angle of 25° to the horizontal. A box of weight 80 newtons is on the slope. A rope is attached to the box and is parallel to the slope. The tension in the rope is of magnitude T newtons. The diagram shows the slope, the box and the rope.



(a) The box is held in equilibrium by the rope.

(i) Show that the normal reaction force between the box and the slope is 72.5 newtons, correct to three significant figures. *(3 marks)*

(ii) The coefficient of friction between the box and the slope is 0.32. Find the magnitude of the maximum value of the frictional force which can act on the box. *(2 marks)*

(iii) Find the least possible tension in the rope to prevent the box from moving down the slope. *(4 marks)*

(iv) Find the greatest possible tension in the rope. *(3 marks)*

(v) Show that the mass of the box is approximately 8.16 kg. *(1 mark)*

(b) The rope is now released and the box slides down the slope. Find the acceleration of the box. *(3 marks)*

END OF QUESTIONS

Practice 3

Leave blank

1. Two particles A and B have masses 4 kg and m kg respectively. They are moving towards each other in opposite directions on a smooth horizontal table when they collide directly. Immediately before the collision, the speed of A is 5 m s^{-1} and the speed of B is 3 m s^{-1}. Immediately after the collision, the direction of motion of A is unchanged and the speed of A is 1 m s^{-1}.

(a) Find the magnitude of the impulse exerted on A in the collision.

(2)

Immediately after the collision, the speed of B is 2 m s^{-1}.

(b) Find the value of m.

(4)

Leave blank

Question 1 continued

Q1

(Total 6 marks)

Turn over

Leave blank

2. A firework rocket starts from rest at ground level and moves vertically. In the first 3 s of its motion, the rocket rises 27 m. The rocket is modelled as a particle moving with constant acceleration a m s^{-2}. Find

(a) the value of a,

(2)

(b) the speed of the rocket 3 s after it has left the ground.

(2)

After 3 s, the rocket burns out. The motion of the rocket is now modelled as that of a particle moving freely under gravity.

(c) Find the height of the rocket above the ground 5 s after it has left the ground.

(4)

Leave blank

Question 2 continued

(Total 8 marks)

Q2

Turn over

Leave blank

3. A car moves along a horizontal straight road, passing two points A and B. At A the speed of the car is 15 m s^{-1}. When the driver passes A, he sees a warning sign W ahead of him, 120 m away. He immediately applies the brakes and the car decelerates with uniform deceleration, reaching W with speed 5 m s^{-1}. At W, the driver sees that the road is clear. He then immediately accelerates the car with uniform acceleration for 16 s to reach a speed of V m s^{-1} ($V > 15$). He then maintains the car at a constant speed of V m s^{-1}. Moving at this constant speed, the car passes B after a further 22 s.

(a) Sketch, in the space below, a speed-time graph to illustrate the motion of the car as it moves from A to B.

(3)

(b) Find the time taken for the car to move from A to B.

(3)

The distance from A to B is 1 km.

(c) Find the value of V.

(5)

Leave blank

Question 3 continued

Leave blank

Question 3 continued

Question 3 continued

Leave blank

(Total 11 marks)

Q3

Leave blank

4.

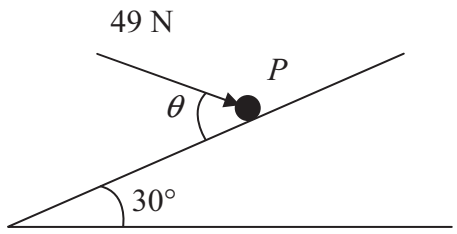


Figure 1

A particle P of mass 6 kg lies on the surface of a smooth plane. The plane is inclined at an angle of 30° to the horizontal. The particle is held in equilibrium by a force of magnitude 49 N, acting at an angle θ to the plane, as shown in Figure 1. The force acts in a vertical plane through a line of greatest slope of the plane.

(a) Show that $\cos\theta = \frac{3}{5}$.

(3)

(b) Find the normal reaction between P and the plane.

(4)

The direction of the force of magnitude 49 N is now changed. It is now applied horizontally to P so that P moves up the plane. The force again acts in a vertical plane through a line of greatest slope of the plane.

(c) Find the initial acceleration of P.

(4)

Leave blank

Question 4 continued

Turn over

Leave blank

Question 4 continued

Leave blank

Question 4 continued

(Total 11 marks)

Q4

Turn over

Leave blank

5.

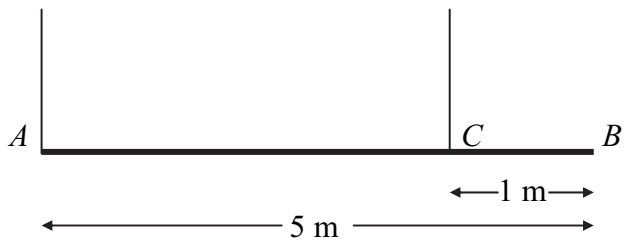


Figure 2

A beam AB has mass 12 kg and length 5 m. It is held in equilibrium in a horizontal position by two vertical ropes attached to the beam. One rope is attached to A, the other to the point C on the beam, where $BC = 1$ m, as shown in Figure 2. The beam is modelled as a uniform rod, and the ropes as light strings.

(a) Find

(i) the tension in the rope at C,

(ii) the tension in the rope at A.

(5)

A small load of mass 16 kg is attached to the beam at a point which is y metres from A. The load is modelled as a particle. Given that the beam remains in equilibrium in a horizontal position,

(b) find, in terms of y, an expression for the tension in the rope at C.

(3)

The rope at C will break if its tension exceeds 98 N. The rope at A cannot break.

(c) Find the range of possible positions on the beam where the load can be attached without the rope at C breaking.

(3)

Question 5 continued

Leave blank

Turn over

Leave blank

Question 5 continued

Leave blank

Question 5 continued

(Total 11 marks)

Q5

Leave blank

6. [*In this question, the unit vectors* **i** *and* **j** *are due east and due north respectively.*]

A particle P is moving with constant velocity $(-5\mathbf{i} + 8\mathbf{j})$ m s^{-1}. Find

(a) the speed of P,

(2)

(b) the direction of motion of P, giving your answer as a bearing.

(3)

At time $t = 0$, P is at the point A with position vector $(7\mathbf{i} - 10\mathbf{j})$ m relative to a fixed origin O. When $t = 3$ s, the velocity of P changes and it moves with velocity $(u\mathbf{i} + v\mathbf{j})$ m s^{-1}, where u and v are constants. After a further 4 s, it passes through O and continues to move with velocity $(u\mathbf{i} + v\mathbf{j})$ m s^{-1}.

(c) Find the values of u and v.

(5)

(d) Find the total time taken for P to move from A to a position which is due south of A.

(3)

Leave blank

Question 6 continued

Question 6 continued

Leave blank

Leave blank

Question 6 continued

(Total 13 marks)

Q6

Turn over

Leave blank

7.

Figure 3

Two particles A and B, of mass m and $2m$ respectively, are attached to the ends of a light inextensible string. The particle A lies on a rough horizontal table. The string passes over a small smooth pulley P fixed on the edge of the table. The particle B hangs freely below the pulley, as shown in Figure 3. The coefficient of friction between A and the table is μ. The particles are released from rest with the string taut. Immediately after release, the magnitude of the acceleration of A and B is $\frac{4}{9}g$. By writing down separate equations of motion for A and B,

(a) find the tension in the string immediately after the particles begin to move,

(3)

(b) show that $\mu = \frac{2}{3}$.

(5)

When B has fallen a distance h, it hits the ground and does not rebound. Particle A is then a distance $\frac{1}{3}h$ from P.

(c) Find the speed of A as it reaches P.

(6)

(d) State how you have used the information that the string is light.

(1)

Leave blank

Question 7 continued

Leave blank

Question 7 continued

Leave blank

Question 7 continued

Q7

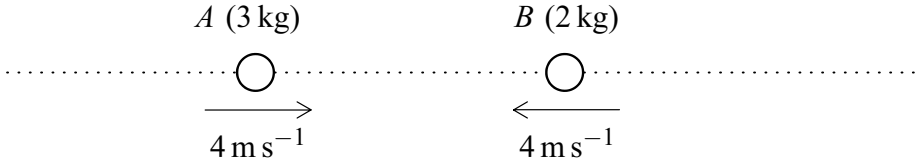
(Total 15 marks)

TOTAL FOR PAPER: 75 MARKS

END

Answer **all** questions.

1 Two particles A and B have masses of 3 kg and 2 kg respectively. They are moving along a straight horizontal line towards each other. Each particle is moving with a speed of $4\,\text{m s}^{-1}$ when they collide.



(a) If the particles coalesce during the collision to form a single particle, find the speed of the combined particle after the collision. *(3 marks)*

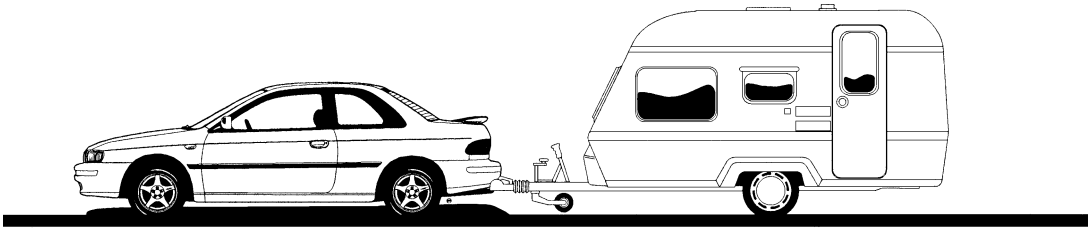
(b) If, after the collision, A moves in the same direction as before the collision with speed $0.4\,\text{m s}^{-1}$, find the speed of B after the collision. *(3 marks)*

2 A motorcycle accelerates uniformly along a straight horizontal road so that, when it has travelled 20 metres, its velocity has increased from $12\,\text{m s}^{-1}$ to $16\,\text{m s}^{-1}$.

(a) Find the acceleration of the motorcycle. *(3 marks)*

(b) Find the time that it takes for the motorcycle to travel this distance. *(3 marks)*

3 A car, of mass 1500 kg, is towing a caravan, of mass 900 kg, along a straight horizontal road. The caravan is connected to the car by a horizontal tow bar. Resistance forces of magnitudes 400 N and 800 N act on the car and caravan respectively. The acceleration of the car and caravan is $0.8\,\text{m s}^{-2}$.



(a) Show that the magnitude of the force that the car exerts on the caravan is 1520 N. *(3 marks)*

(b) Find the magnitude of the driving force produced by the car's engine. *(3 marks)*

4 A cricket ball is hit from the floor of a sports hall, which has a height of 6 metres. The initial velocity of the ball is $20\,\mathrm{m\,s^{-1}}$ at an angle of 60° above the horizontal.

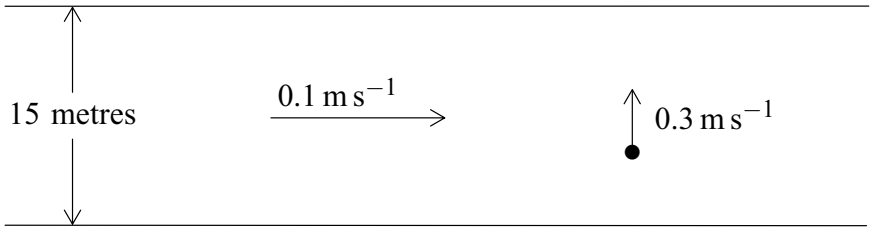
Assume that the cricket ball is a particle which moves only under the influence of gravity.

(a) Show that the ball hits the ceiling of the sports hall approximately 0.389 seconds after it was hit. *(5 marks)*

(b) Find the horizontal distance travelled by the ball before it hits the ceiling. *(2 marks)*

(c) Find the speed of the ball just before it hits the ceiling. *(5 marks)*

5 A girl in a boat is rowing across a river, in which the water is flowing at $0.1\,\mathrm{m\,s^{-1}}$. The velocity of the boat relative to the water is $0.3\,\mathrm{m\,s^{-1}}$ and is perpendicular to the bank, as shown in the diagram.



(a) Find the magnitude of the resultant velocity of the boat. *(2 marks)*

(b) Find the acute angle between the resultant velocity and the bank. *(3 marks)*

(c) The width of the river is 15 metres.

(i) Find the time that it takes the boat to cross the river. *(2 marks)*

(ii) Find the total distance travelled by the boat as it crosses the river. *(2 marks)*

Turn over for the next question

6 A trolley, of mass 100 kg, rolls at a constant speed along a straight line down a slope inclined at an angle of 4° to the horizontal.

Assume that a constant resistance force, of magnitude P newtons, acts on the trolley as it moves. Model the trolley as a particle.

(a) Draw a diagram to show the forces acting on the trolley. *(1 mark)*

(b) Show that $P = 68.4\,\text{N}$, correct to three significant figures. *(3 marks)*

(c) (i) Find the acceleration of the trolley if it rolls down a slope inclined at 5° to the horizontal and experiences the same constant force of magnitude P that you found in part (b). *(4 marks)*

(ii) Make one criticism of the assumption that the resistance force on the trolley is constant. *(1 mark)*

7 A particle is initially at the origin, where it has velocity $(5\mathbf{i} - 2\mathbf{j})\,\text{m s}^{-1}$. It moves with a constant acceleration $\mathbf{a}\,\text{m s}^{-2}$ for 10 seconds to the point with position vector $75\mathbf{i}$ metres.

(a) Show that $\mathbf{a} = 0.5\mathbf{i} + 0.4\mathbf{j}$. *(3 marks)*

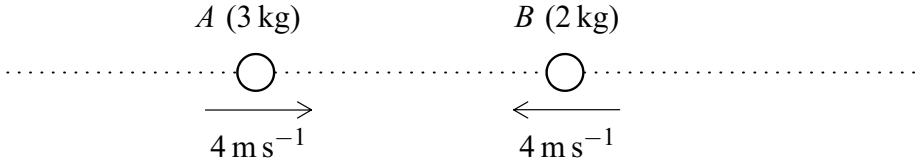
(b) Find the position vector of the particle 8 seconds after it has left the origin. *(3 marks)*

(c) Find the position vector of the particle when it is travelling parallel to the unit vector $\mathbf{i}$. *(6 marks)*

END OF QUESTIONS

Answer **all** questions.

1 Two particles A and B have masses of 3 kg and 2 kg respectively. They are moving along a straight horizontal line towards each other. Each particle is moving with a speed of $4\,\mathrm{m\,s^{-1}}$ when they collide.



(a) If the particles coalesce during the collision to form a single particle, find the speed of the combined particle after the collision. *(3 marks)*

(b) If, after the collision, A moves in the same direction as before the collision with speed $0.4\,\mathrm{m\,s^{-1}}$, find the speed of B after the collision. *(3 marks)*

2 A lift rises vertically from rest with a constant acceleration.

After 4 seconds, it is moving upwards with a velocity of $2\,\mathrm{m\,s^{-1}}$.

It then moves with a constant velocity for 5 seconds.

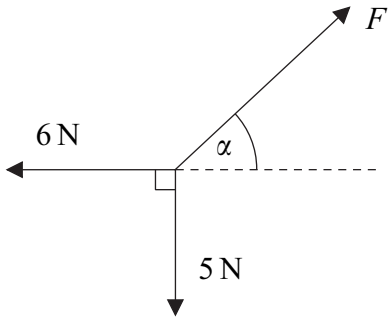
The lift then slows down uniformly, coming to rest after it has been moving for a total of 12 seconds.

(a) Sketch a velocity–time graph for the motion of the lift. *(4 marks)*

(b) Calculate the total distance travelled by the lift. *(2 marks)*

(c) The lift is raised by a single vertical cable. The mass of the lift is 300 kg. Find the maximum tension in the cable during this motion. *(4 marks)*

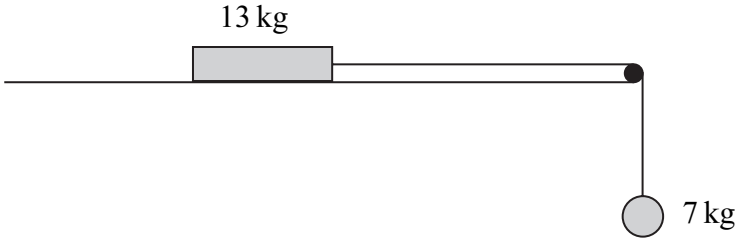
3 The diagram shows three forces which act in the same plane and are in equilibrium.



(a) Find F. *(3 marks)*

(b) Find α. *(3 marks)*

4 The diagram shows a block, of mass 13 kg, on a rough horizontal surface. It is attached by a string that passes over a smooth peg to a sphere of mass 7 kg, as shown in the diagram.



The system is released from rest, and after 4 seconds the block and the sphere both have speed $6\,\text{m}\,\text{s}^{-1}$, and the block has **not** reached the peg.

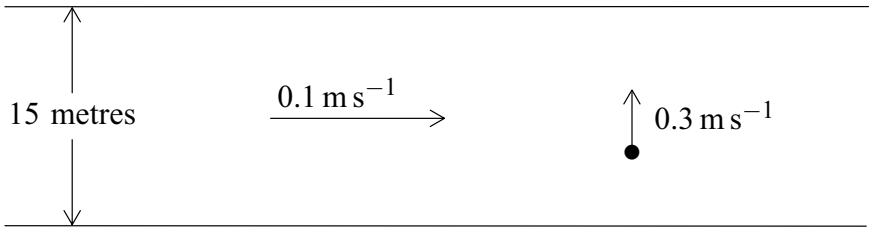
(a) State **two** assumptions that you should make about the string in order to model the motion of the sphere and the block. *(2 marks)*

(b) Show that the acceleration of the sphere is $1.5\,\text{m}\,\text{s}^{-2}$. *(2 marks)*

(c) Find the tension in the string. *(3 marks)*

(d) Find the coefficient of friction between the block and the surface. *(6 marks)*

5 A girl in a boat is rowing across a river, in which the water is flowing at $0.1\,\text{m}\,\text{s}^{-1}$. The velocity of the boat relative to the water is $0.3\,\text{m}\,\text{s}^{-1}$ and is perpendicular to the bank, as shown in the diagram.



(a) Find the magnitude of the resultant velocity of the boat. *(2 marks)*

(b) Find the acute angle between the resultant velocity and the bank. *(3 marks)*

(c) The width of the river is 15 metres.

(i) Find the time that it takes the boat to cross the river. *(2 marks)*

(ii) Find the total distance travelled by the boat as it crosses the river. *(2 marks)*

6 A trolley, of mass 100 kg, rolls at a constant speed along a straight line down a slope inclined at an angle of 4° to the horizontal.

Assume that a constant resistance force, of magnitude P newtons, acts on the trolley as it moves. Model the trolley as a particle.

(a) Draw a diagram to show the forces acting on the trolley. *(1 mark)*

(b) Show that $P = 68.4\,\text{N}$, correct to three significant figures. *(3 marks)*

(c) (i) Find the acceleration of the trolley if it rolls down a slope inclined at 5° to the horizontal and experiences the same constant force of magnitude P that you found in part (b). *(4 marks)*

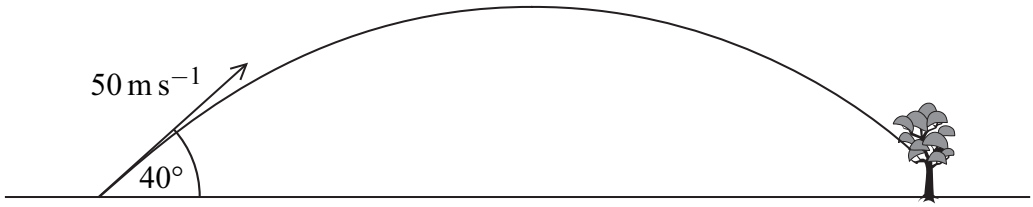
(ii) Make one criticism of the assumption that the resistance force on the trolley is constant. *(1 mark)*

7 A golf ball is struck from a point on horizontal ground so that it has an initial velocity of $50\,\text{m}\,\text{s}^{-1}$ at an angle of $40°$ above the horizontal.

Assume that the golf ball is a particle and its weight is the only force that acts on it once it is moving.

(a) Find the maximum height of the golf ball. *(4 marks)*

(b) After it has reached its maximum height, the golf ball descends but hits a tree at a point which is at a height of 6 metres above ground level.



Find the time that it takes for the ball to travel from the point where it was struck to the tree. *(6 marks)*

8 A particle is initially at the origin, where it has velocity $(5\mathbf{i} - 2\mathbf{j})\,\text{m}\,\text{s}^{-1}$. It moves with a constant acceleration $\mathbf{a}\,\text{m}\,\text{s}^{-2}$ for 10 seconds to the point with position vector $75\mathbf{i}$ metres.

(a) Show that $\mathbf{a} = 0.5\mathbf{i} + 0.4\mathbf{j}$. *(3 marks)*

(b) Find the position vector of the particle 8 seconds after it has left the origin. *(3 marks)*

(c) Find the position vector of the particle when it is travelling parallel to the unit vector $\mathbf{i}$. *(6 marks)*

END OF QUESTIONS

Practice 6

Leave blank

1. A particle P moves with constant acceleration $(2\mathbf{i} - 5\mathbf{j})$ m s^{-2}. At time $t = 0$, P has speed u m s^{-1}. At time $t = 3$ s, P has velocity $(-6\mathbf{i} + \mathbf{j})$ m s^{-1}.

Find the value of u.

(5)

Leave blank

Question 1 continued

(Total 5 marks)

Q1

Turn over

Leave blank

2. A small ball is projected vertically upwards from ground level with speed u m s^{-1}. The ball takes 4 s to return to ground level.

(a) Draw, in the space below, a velocity-time graph to represent the motion of the ball during the first 4 s.

(2)

(b) The maximum height of the ball above the ground during the first 4 s is 19.6 m. Find the value of u.

(3)

Leave blank

Question 2 continued

(Total 5 marks)

Q2

Turn over

Leave blank

3. Two particles A and B are moving on a smooth horizontal plane. The mass of A is km, where $2 < k < 3$, and the mass of B is m. The particles are moving along the same straight line, but in opposite directions, and they collide directly. Immediately before they collide the speed of A is $2u$ and the speed of B is $4u$. As a result of the collision the speed of A is halved and its direction of motion is reversed.

(a) Find, in terms of k and u, the speed of B immediately after the collision.

(3)

(b) State whether the direction of motion of B changes as a result of the collision, explaining your answer.

(3)

Given that $k = \frac{7}{3}$,

(c) find, in terms of m and u, the magnitude of the impulse that A exerts on B in the collision.

(3)

Question 3 continued

Leave blank

(Total 9 marks)

Q3

Turn over

Leave blank

4.

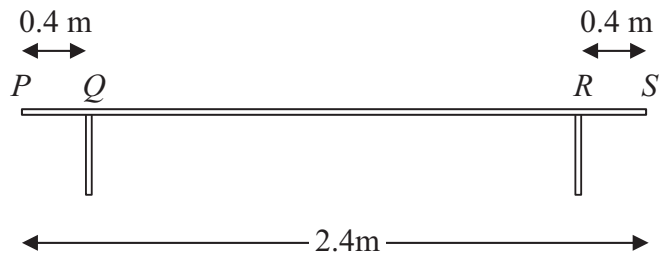


Figure 1

A bench consists of a plank which is resting in a horizontal position on two thin vertical legs. The plank is modelled as a uniform rod PS of length 2.4 m and mass 20 kg. The legs at Q and R are 0.4 m from each end of the plank, as shown in Figure 1.

Two pupils, Arthur and Beatrice, sit on the plank. Arthur has mass 60 kg and sits at the middle of the plank and Beatrice has mass 40 kg and sits at the end P. The plank remains horizontal and in equilibrium. By modelling the pupils as particles, find

(a) the magnitude of the normal reaction between the plank and the leg at Q and the magnitude of the normal reaction between the plank and the leg at R.

(7)

Beatrice stays sitting at P but Arthur now moves and sits on the plank at the point X. Given that the plank remains horizontal and in equilibrium, and that the magnitude of the normal reaction between the plank and the leg at Q is now twice the magnitude of the normal reaction between the plank and the leg at R,

(b) find the distance QX.

(6)

Leave blank

Question 4 continued

Leave blank

Question 4 continued

Leave blank

Question 4 continued

(Total 13 marks)

Q4

Turn over

Leave blank

5.

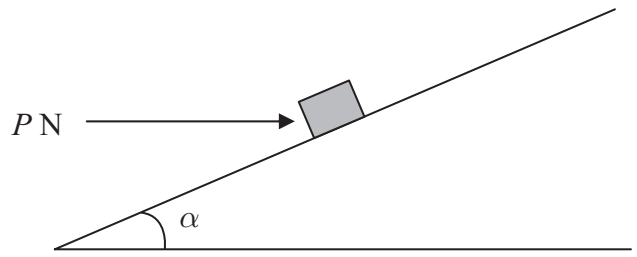


Figure 2

A small package of mass 1.1 kg is held in equilibrium on a rough plane by a horizontal force. The plane is inclined at an angle α to the horizontal, where $\tan\alpha=\frac{3}{4}$. The force acts in a vertical plane containing a line of greatest slope of the plane and has magnitude P newtons, as shown in Figure 2.

The coefficient of friction between the package and the plane is 0.5 and the package is modelled as a particle. The package is in equilibrium and on the point of slipping down the plane.

(a) Draw, on Figure 2, all the forces acting on the package, showing their directions clearly.

(2)

(b) (i) Find the magnitude of the normal reaction between the package and the plane.

(ii) Find the value of P.

(11)

Leave blank

Question 5 continued

Leave blank

Question 5 continued

Leave blank

Question 5 continued

(Total 13 marks)

Q5

Turn over

Leave blank

6. Two forces, $(4\mathbf{i} - 5\mathbf{j})$ N and $(p\mathbf{i} + q\mathbf{j})$ N, act on a particle P of mass m kg. The resultant of the two forces is **R**. Given that **R** acts in a direction which is parallel to the vector $(\mathbf{i} - 2\mathbf{j})$,

(a) find the angle between **R** and the vector **j**,

(3)

(b) show that $2p + q + 3 = 0$.

(4)

Given also that $q = 1$ and that P moves with an acceleration of magnitude $8\sqrt{5}$ m s^{-2},

(c) find the value of m.

(7)

Leave blank

Question 6 continued

Leave blank

Question 6 continued

Leave blank

Question 6 continued

(Total 14 marks)

Q6

Leave blank

7.

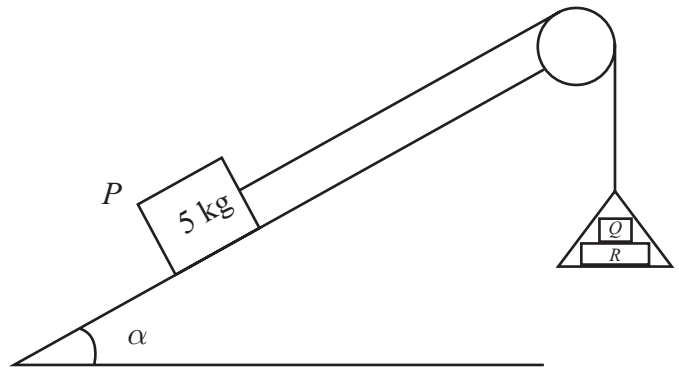


Figure 3

One end of a light inextensible string is attached to a block P of mass 5 kg. The block P is held at rest on a smooth fixed plane which is inclined to the horizontal at an angle α, where $\sin\alpha = \frac{3}{5}$. The string lies along a line of greatest slope of the plane and passes over a smooth light pulley which is fixed at the top of the plane. The other end of the string is attached to a light scale pan which carries two blocks Q and R, with block Q on top of block R, as shown in Figure 3. The mass of block Q is 5 kg and the mass of block R is 10 kg. The scale pan hangs at rest and the system is released from rest. By modelling the blocks as particles, ignoring air resistance and assuming the motion is uninterrupted, find

(a) (i) the acceleration of the scale pan,

(ii) the tension in the string,

(8)

(b) the magnitude of the force exerted on block Q by block R,

(3)

(c) the magnitude of the force exerted on the pulley by the string.

(5)

Leave blank

Question 7 continued

Leave blank

Question 7 continued

Leave blank

Question 7 continued

Q7

(Total 16 marks)

TOTAL FOR PAPER: 75 MARKS

END