2. Two particles, *A* and *B*, are moving in a straight line in opposite directions towards each other on a smooth horizontal surface when they collide directly.

Particle *A* has mass $3m$ kg and particle *B* has mass m kg.

Immediately before the collision, both particles have a speed of $1.5\,\mathrm{m\,s^{-1}}$

Immediately after the collision, the direction of motion of *A* is unchanged and the difference between the speed of *A* and speed of *B* is $1\,\mathrm{m\,s^{-1}}$

(a) Find   (i) the speed of *A* immediately after the collision,

   (ii) the speed of *B* immediately after the collision.

(5)

(b) Find, in terms of *m*, the magnitude of the impulse exerted on *B* in the collision.

(3)

P 7 2 0 7 0 A 0 4 2 8

Question 2 continued

(Total for Question 2 is 8 marks)

3. A particle P is moving with constant acceleration $(-4\mathbf{i} + \mathbf{j})\,\text{m}\,\text{s}^{-2}$

At time $t = 0$, P has velocity $(14\mathbf{i} - 5\mathbf{j})\,\text{m}\,\text{s}^{-1}$

(a) Find the speed of P at time $t = 2$ seconds.

(3)

(b) Find the size of the angle between the direction of $\mathbf{i}$ and the direction of motion of P at time $t = 2$ seconds.

(3)

At time $t = T$ seconds, P is moving in the direction of vector $(2\mathbf{i} - 3\mathbf{j})$

(c) Find the value of T

(4)

Question 3 continued

Question 3 continued

Question 3 continued

(Total for Question 3 is 10 marks)

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4.
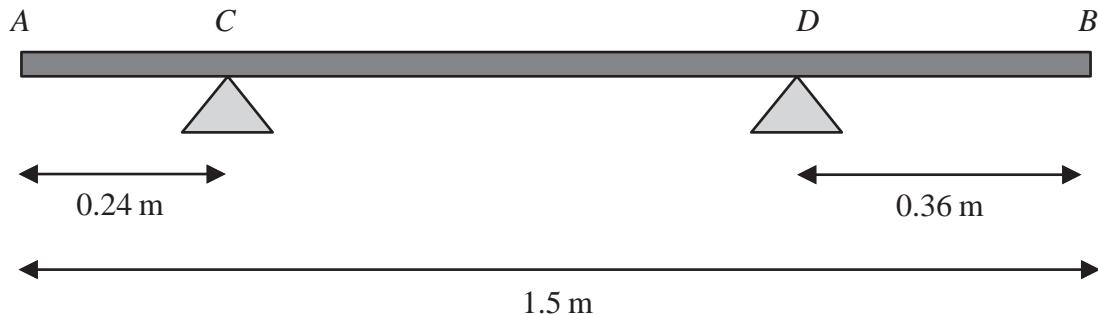
Figure 1

A branch *AB*, of length 1.5 m, rests horizontally in equilibrium on two supports.

The two supports are at the points *C* and *D*, where $AC = 0.24\,\text{m}$ and $DB = 0.36\,\text{m},$ as shown in Figure 1.

When a force of 150 N is applied vertically upwards at *B*, the branch is on the point of tilting about *C*.

When a force of 225 N is applied vertically downwards at *B*, the branch is on the point of tilting about *D*.

The branch is modelled as a non-uniform rod *AB* of weight *W* newtons.

The distance from the point *C* to the centre of mass of the rod is *x* metres.

Use the model to find

(i) the value of *W*

(ii) the value of *x*

(8)

Question 4 continued

P72070A01128

Question 4 continued
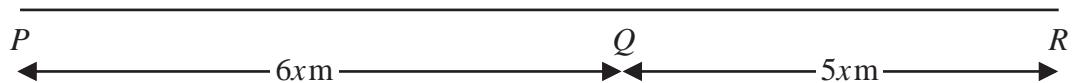
Question 4 continued

(Total for Question 4 is 8 marks)

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5.

Figure 2

Three points P, Q and R are on a horizontal road where PQR is a straight line.

The point Q is between P and R, with $PQ = 6x$ metres and $QR = 5x$ metres, as shown in Figure 2.

A vehicle moves along the road from P to Q with constant acceleration.

The vehicle is modelled as a particle.

At time $t = 0$, the vehicle passes P with speed $u\,\mathrm{m\,s^{-1}}$

At time $t = 12$ s, the vehicle passes Q with speed $2u\,\mathrm{m\,s^{-1}}$

Using the model,

(a) show that $x = 3u$

(2)

As the vehicle passes Q, the acceleration of the vehicle changes instantaneously to $1.5\,\mathrm{m\,s^{-2}}$

The vehicle continues to move with a constant acceleration of $1.5\,\mathrm{m\,s^{-2}}$ and passes R with speed $3u\,\mathrm{m\,s^{-1}}$

Using the model,

(b) find the value of u,

(3)

(c) find the distance travelled by the vehicle during the first 14 seconds after passing P

(4)

Question 5 continued

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Question 5 continued
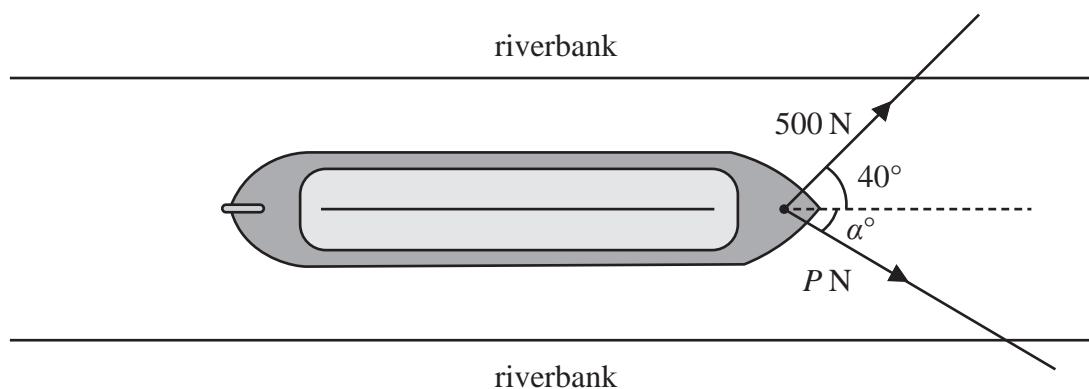
Question 5 continued

(Total for Question 5 is 9 marks)

6.

Figure 3

A boat is pulled along a river at a constant speed by two ropes.

The banks of the river are parallel and the boat travels horizontally in a straight line, parallel to the riverbanks.

- The tension in the first rope is $500\,\text{N}$ acting at an angle of $40°$ to the direction of motion, as shown in Figure 3.

- The tension in the second rope is P newtons, acting at an angle of $\alpha°$ to the direction of motion, also shown in Figure 3.

- The resistance to motion of the boat as it moves through the water is a constant force of magnitude $900\,\text{N}$

The boat is modelled as a particle. The ropes are modelled as being light and lying in a horizontal plane.

Use the model to find

   (i) the value of α

  (ii) the value of P

(8)

Question 6 continued

Question 6 continued

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Question 6 continued
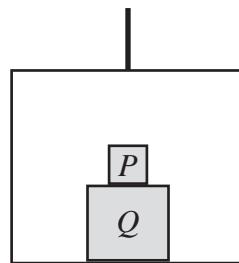
(Total for Question 6 is 8 marks)

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7.

Figure 4

A simple lift operates by means of a vertical cable which is attached to the top of the lift.
The lift has mass m
A box Q is placed on the floor of the lift.
A box P is placed directly on top of box Q, as shown in Figure 4.

The cable is modelled as being light and inextensible and air resistance is modelled as being negligible.

The tension in the cable is $\dfrac{42mg}{5}$

The lift and its contents move vertically upwards with acceleration $\dfrac{2g}{5}$

Using the model,

(a) find, in terms of m, the combined mass of boxes P and Q

(4)

During the motion of the lift, the force exerted on box P by box Q is $\dfrac{14mg}{5}$

Using the model,

(b) find, in terms of m, the mass of box P

(3)
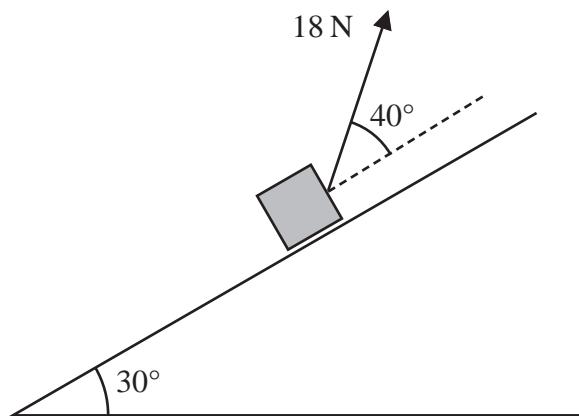
Question 7 continued

(Total for Question 7 is 7 marks)

8.

18 N

40°

30°

Figure 5

A parcel of mass 2 kg is pulled up a rough inclined plane by the action of a constant force.

The force has magnitude 18 N and acts at an angle of 40° to the plane.

The line of action of the force lies in a vertical plane containing a line of greatest slope of the inclined plane.

The plane is inclined at an angle of 30° to the horizontal, as shown in Figure 5.

The coefficient of friction between the plane and the parcel is 0.3

The parcel is modelled as a particle *P*

(a) Find the acceleration of *P*

(8)

The points *A* and *B* lie on a line of greatest slope of the plane, where *AB* = 5 m and *B* is above *A*. Particle *P* passes through *A* with speed $2\,\mathrm{m\,s^{-1}}$ in the direction *AB*.

(b) Find the speed of *P* as it passes through *B*.

(3)

The force of 18 N is removed at the instant *P* passes through *B*. As a result, *P* comes to rest at the point *C*.

(c) Determine whether *P* will remain at rest at *C*. You must show all stages of your working clearly.

(4)

Question 8 continued

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Question 8 continued

Question 8 continued

P 7 2 0 7 0 A 0 2 7 2 8

Question 8 continued

(Total for Question 8 is 15 marks)

TOTAL FOR PAPER: 75 MARKS

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