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1. Two particles A and B have masses 4 kg and $m\text{ kg}$ 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)

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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 $a \text{ m s}^{-2}$. 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)

Horizontal lines for writing answers.



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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 $V \text{ m s}^{-1}$ ($V > 15$). He then maintains the car at a constant speed of $V \text{ m s}^{-1}$. 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)



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Question 3 continued

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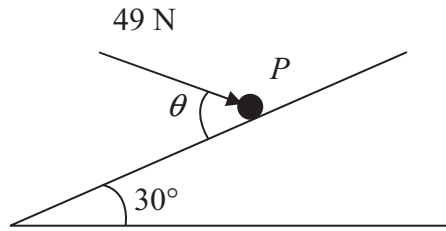


Figure 1

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)



5.

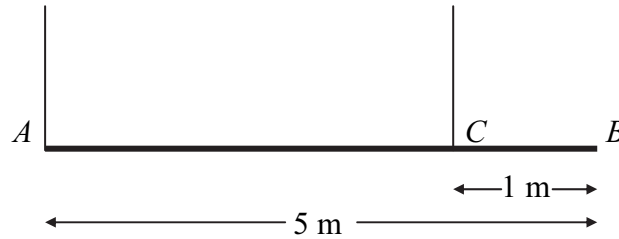


Figure 2

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)



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- 6. [In this question, the unit vectors \mathbf{i} and \mathbf{j} are due east and due north respectively.]

A particle P is moving with constant velocity $(-5\mathbf{i} + 8\mathbf{j}) \text{ m s}^{-1}$. 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 $(7\mathbf{i} - 10\mathbf{j}) \text{ m}$ relative to a fixed origin O . When $t = 3 \text{ s}$, the velocity of P changes and it moves with velocity $(u\mathbf{i} + v\mathbf{j}) \text{ m s}^{-1}$, where u and v are constants. After a further 4 s, it passes through O and continues to move with velocity $(u\mathbf{i} + v\mathbf{j}) \text{ m s}^{-1}$.

- (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)



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Question 6 continued

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Question 6 continued

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Q6

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(Total 13 marks)



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)



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Question 7 continued

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(Total 15 marks)

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Q7



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