

Mechanics-M1 - 2013-June

Question 1

Particle P has mass 3 kg and particle Q has mass m kg. The particles are moving in opposite directions along a smooth horizontal plane when they collide directly. Immediately before the collision, the speed of P is 4 m s^{-1} and the speed of Q is 3 m s^{-1} . In the collision the direction of motion of P is unchanged and the direction of motion of Q is reversed. Immediately after the collision, the speed of P is 1 m s^{-1} and the speed of Q is 1.5 m s^{-1} .

- (a) Find the magnitude of the impulse exerted on P in the collision. (3)
- (b) Find the value of m . (3)
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Question 2

A woman travels in a lift. The mass of the woman is 50 kg and the mass of the lift is 950 kg. The lift is being raised vertically by a vertical cable which is attached to the top of the lift. The lift is moving upwards and has constant deceleration of 2 m s^{-2} . By modelling the cable as being light and inextensible, find

- (a) the tension in the cable, (3)
- (b) the magnitude of the force exerted on the woman by the floor of the lift. (3)
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Question 3

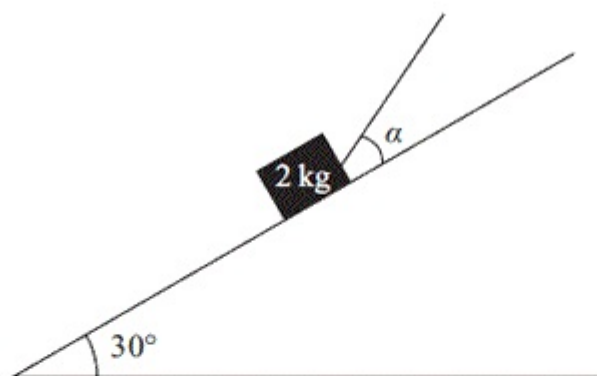


Figure 1

A box of mass 2 kg is held in equilibrium on a fixed rough inclined plane by a rope. The rope lies in a vertical plane containing a line of greatest slope of the inclined plane. The rope is inclined to the plane at an angle α , where $\tan \alpha = \frac{3}{4}$, and the plane is at an angle of 30° to the horizontal, as shown in Figure 1. The coefficient of friction between the box and the inclined plane is $\frac{1}{3}$ and the box is on the point of slipping up the plane. By modelling the box as a particle and the rope as a light inextensible string, find the tension in the rope. (8)

Question 4

A lorry is moving along a straight horizontal road with constant acceleration. The lorry passes a point A with speed $u \text{ m s}^{-1}$, ($u < 34$), and 10 seconds later passes a point B with speed 34 m s^{-1} . Given that $AB = 240 \text{ m}$, find

- (a) the value of u , (3)
 - (b) the time taken for the lorry to move from A to the mid-point of AB . (6)
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Question 5

A car is travelling along a straight horizontal road. The car takes 120 s to travel between two sets of traffic lights which are 2145 m apart. The car starts from rest at the first set of traffic lights and moves with constant acceleration for 30 s until its speed is 22 m s^{-1} . The car maintains this speed for T seconds. The car then moves with constant deceleration, coming to rest at the second set of traffic lights.

- (a) Sketch, in the space below, a speed-time graph for the motion of the car between the two sets of traffic lights.

(2)

- (b) Find the value of T .

(3)

A motorcycle leaves the first set of traffic lights 10 s after the car has left the first set of traffic lights. The motorcycle moves from rest with constant acceleration, $a \text{ m s}^{-2}$, and passes the car at the point A which is 990 m from the first set of traffic lights. When the motorcycle passes the car, the car is moving with speed 22 m s^{-1} .

- (c) Find the time it takes for the motorcycle to move from the first set of traffic lights to the point A .

(4)

- (d) Find the value of a .

(2)

Question 6

A beam AB has length 15 m. The beam rests horizontally in equilibrium on two smooth supports at the points P and Q , where $AP = 2 \text{ m}$ and $QB = 3 \text{ m}$. When a child of mass 50 kg stands on the beam at A , the beam remains in equilibrium and is on the point of tilting about P . When the same child of mass 50 kg stands on the beam at B , the beam remains in equilibrium and is on the point of tilting about Q . The child is modelled as a particle and the beam is modelled as a non-uniform rod.

- (a) (i) Find the mass of the beam.

- (ii) Find the distance of the centre of mass of the beam from A .

(8)

When the child stands at the point X on the beam, it remains horizontal and in equilibrium. Given that the reactions at the two supports are equal in magnitude,

- (b) find AX .

(6)

Question 7

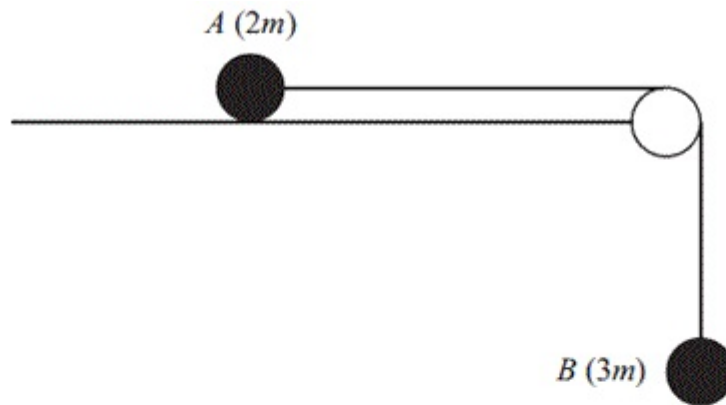


Figure 2

Two particles A and B have masses $2m$ and $3m$ respectively. The particles are attached to the ends of a light inextensible string. Particle A is held at rest on a smooth horizontal table. The string passes over a small smooth pulley which is fixed at the edge of the table. Particle B hangs at rest vertically below the pulley with the string taut, as shown in Figure 2. Particle A is released from rest. Assuming that A has not reached the pulley, find

- (a) the acceleration of B , (5)
 - (b) the tension in the string, (1)
 - (c) the magnitude and direction of the force exerted on the pulley by the string. (4)
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