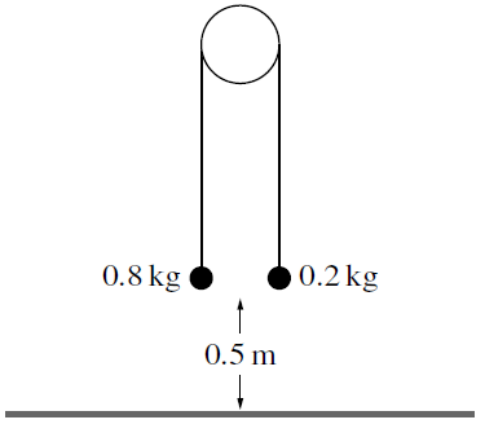
Newton's Laws of Motion – 2020 AS

1. Nov/2020/Paper_9709/41/No.5



Two particles of masses 0.8 kg and 0.2 kg are connected by a light inextensible string that passes over a fixed smooth pulley. The system is released from rest with both particles 0.5 m above a horizontal floor (see diagram). In the subsequent motion the 0.2 kg particle does not reach the pulley.

(a) Show that the magnitude of the acceleration of the particles is 6 m s^{-2} and find the tension in the string. [4]

(b) When the 0.8 kg particle reaches the floor it comes to rest.

Find the greatest height of the 0.2 kg particle above the floor. [3]

2. Nov/2020/Paper_9709/42/No.6

A block of mass 5 kg is placed on a plane inclined at 30° to the horizontal. The coefficient of friction between the block and the plane is μ.

(a)

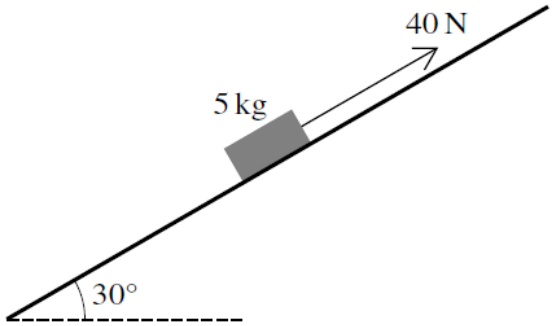


Fig. 6.1

When a force of magnitude 40 N is applied to the block, acting up the plane parallel to a line of greatest slope, the block begins to slide up the plane (see Fig. 6.1).

Show that $\mu < \frac{1}{5}\sqrt{3}$. [4]

(b)

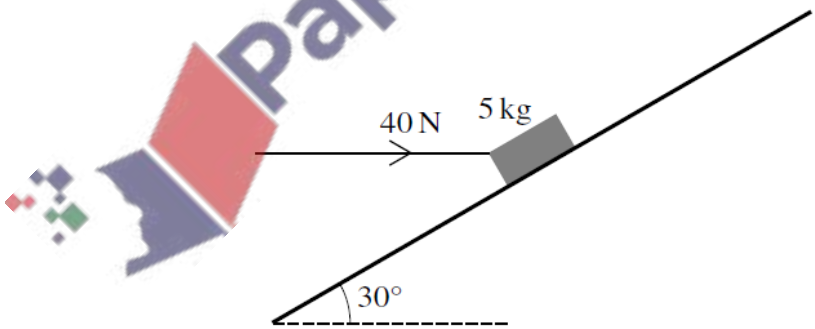


Fig. 6.2

When a force of magnitude 40 N is applied horizontally, in a vertical plane containing a line of greatest slope, the block does not move (see Fig. 6.2).

Show that, correct to 3 decimal places, the least possible value of μ is 0.152. [4]

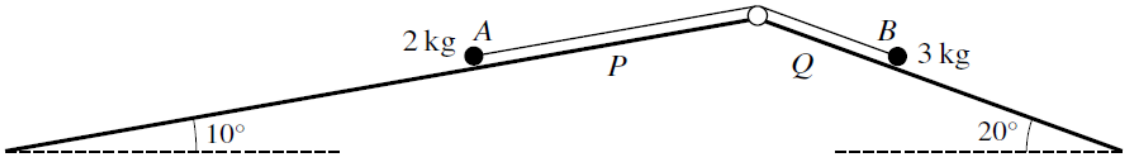
3. Nov/2020/Paper_9709/43/No.3

A string is attached to a block of mass 4 kg which rests in limiting equilibrium on a rough horizontal table. The string makes an angle of 24° above the horizontal and the tension in the string is 30 N.

(a) Draw a diagram showing all the forces acting on the block. [1]

(b) Find the coefficient of friction between the block and the table. [5]

4. Nov/2020/Paper_9709/43/No.7



As shown in the diagram, particles A and B of masses 2 kg and 3 kg respectively are attached to the ends of a light inextensible string. The string passes over a small fixed smooth pulley which is attached to the top of two inclined planes. Particle A is on plane P, which is inclined at an angle of 10° to the horizontal. Particle B is on plane Q, which is inclined at an angle of 20° to the horizontal. The string is taut, and the two parts of the string are parallel to lines of greatest slope of their respective planes.

(a) It is given that plane P is smooth, plane Q is rough, and the particles are in limiting equilibrium.

Find the coefficient of friction between particle B and plane Q. [5]

(b) It is given instead that both planes are smooth and that the particles are released from rest at the same horizontal level.

Find the time taken until the difference in the vertical height of the particles is 1 m. [You should assume that this occurs before A reaches the pulley or B reaches the bottom of plane Q.] [6]

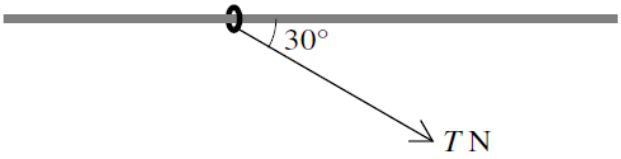
5. June/2020/Paper_9709/41/No.2

A car of mass 1800 kg is towing a trailer of mass 400 kg along a straight horizontal road. The car and trailer are connected by a light rigid tow-bar. The car is accelerating at 1.5 $m\,s^{-2}$. There are constant resistance forces of 250 N on the car and 100 N on the trailer.

(a) Find the tension in the tow-bar. [2]

(b) Find the power of the engine of the car at the instant when the speed is 20 $m\,s^{-1}$. [3]

6. June/2020/Paper_9709/41/No.4

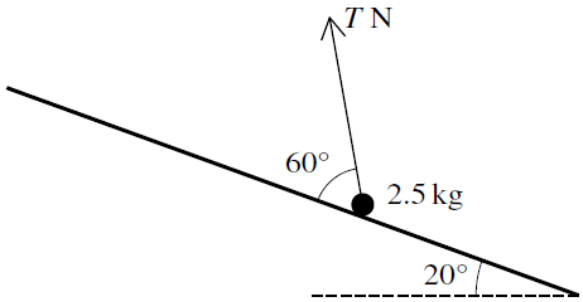


The diagram shows a ring of mass 0.1 kg threaded on a fixed horizontal rod. The rod is rough and the coefficient of friction between the ring and the rod is 0.8. A force of magnitude T N acts on the ring in a direction at 30° to the rod, downwards in the vertical plane containing the rod. Initially the ring is at rest.

(a) Find the greatest value of T for which the ring remains at rest. [4]

(b) Find the acceleration of the ring when $T = 3$. [3]

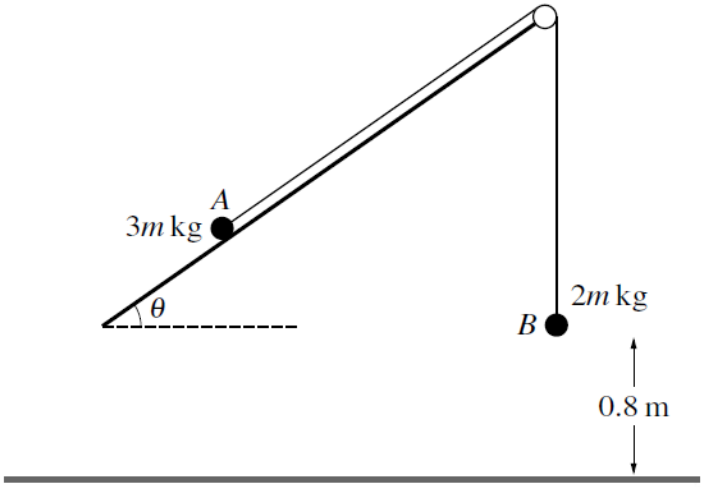
7. June/2020/Paper_9709/42/No.3



A particle of mass 2.5 kg is held in equilibrium on a rough plane inclined at 20° to the horizontal by a force of magnitude T N making an angle of 60° with a line of greatest slope of the plane (see diagram). The coefficient of friction between the particle and the plane is 0.3.

Find the greatest and least possible values of T. [8]

8. June/2020/Paper_9709/43/No.7



Two particles A and B, of masses $3m$ kg and $2m$ kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the edge of a plane. The plane is inclined at an angle θ to the horizontal. A lies on the plane and B hangs vertically, 0.8 m above the floor, which is horizontal. The string between A and the pulley is parallel to a line of greatest slope of the plane (see diagram). Initially A and B are at rest.

(a) Given that the plane is smooth, find the value of θ for which A remains at rest. [3]

It is given instead that the plane is rough, $\theta = 30°$ and the acceleration of A up the plane is 0.1 m s^{-2}.

(b) Show that the coefficient of friction between A and the plane is $\frac{1}{10}\sqrt{3}$. [5]

(c) When B reaches the floor it comes to rest.

Find the length of time after B reaches the floor for which A is moving up the plane. [You may assume that A does not reach the pulley.] [4]

9. March/2020/Paper_9709/42/No.2

A particle P of mass 0.4 kg is on a rough horizontal floor. The coefficient of friction between P and the floor is μ. A force of magnitude 3 N is applied to P upwards at an angle α above the horizontal, where $\tan\alpha = \frac{3}{4}$. The particle is initially at rest and accelerates at $2\,\text{m s}^{-2}$.

(a) Find the time it takes for P to travel a distance of 1.44 m from its starting point. [2]

(b) Find μ. [4]

10. March/2020/Paper_9709/42/No.6

On a straight horizontal test track, driverless vehicles (with no passengers) are being tested. A car of mass 1600 kg is towing a trailer of mass 700 kg along the track. The brakes are applied, resulting in a deceleration of $12\,\text{m s}^{-2}$. The braking force acts on the car only. In addition to the braking force there are constant resistance forces of 600 N on the car and of 200 N on the trailer.

(a) Find the magnitude of the force in the tow-bar. [2]

(b) Find the braking force. [2]

(c) At the instant when the brakes are applied, the car has speed $22\,\text{m s}^{-1}$. At this instant the car is 17.5 m away from a stationary van, which is directly in front of the car.

Show that the car hits the van at a speed of $8\,\text{m s}^{-1}$. [2]

(d) After the collision, the van starts to move with speed $5\,\text{m s}^{-1}$ and the car and trailer continue moving in the same direction with speed $2\,\text{m s}^{-1}$.

Find the mass of the van. [3]