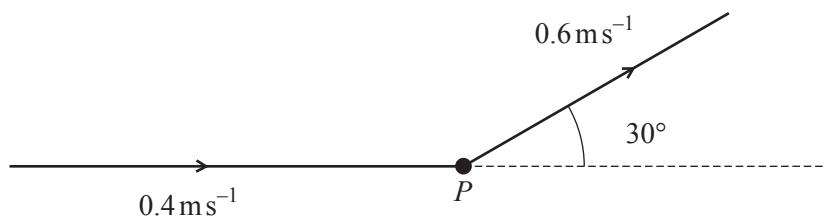


1



A particle P of mass 0.3 kg is moving with speed 0.4 ms^{-1} in a straight line on a smooth horizontal surface when it is struck by a horizontal impulse. After the impulse acts P has speed 0.6 ms^{-1} and is moving in a direction making an angle 30° with its original direction of motion (see diagram).

- (i) Find the magnitude of the impulse and the angle its line of action makes with the original direction of motion of P . [4]

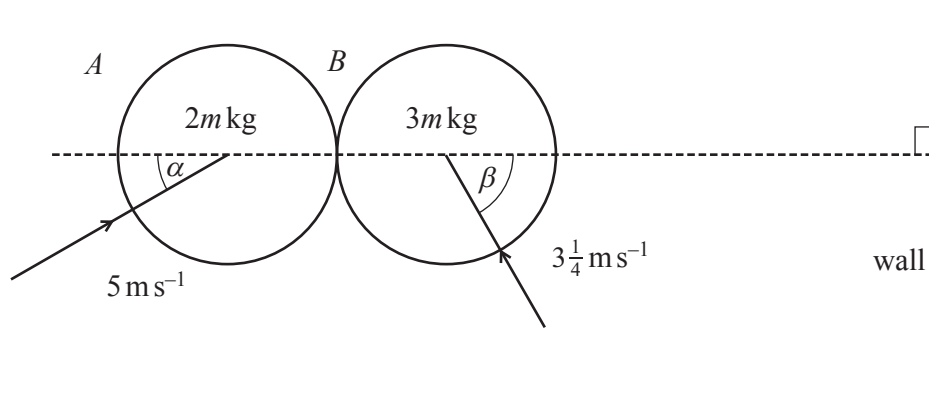
Subsequently a second impulse acts on P . After this second impulse acts, P again moves from left to right with speed 0.4 ms^{-1} in a direction parallel to its original direction of motion.

- (ii) State the magnitude of the second impulse, and show the direction of the second impulse on a diagram. [2]

- 2 A particle Q of mass 0.2 kg is projected horizontally with velocity 4 ms^{-1} from a fixed point A on a smooth horizontal surface. At time $t\text{ s}$ after projection Q is $x\text{ m}$ from A and is moving away from A with velocity $v\text{ ms}^{-1}$. There is a force of $3\cos 2t\text{ N}$ acting on Q in the positive x -direction.

- (i) Find an expression for the velocity of Q at time t . State the maximum and minimum values of the velocity of Q as t varies. [4]
- (ii) Find the average velocity of Q between times $t = \pi$ and $t = \frac{3}{2}\pi$. [4]

3



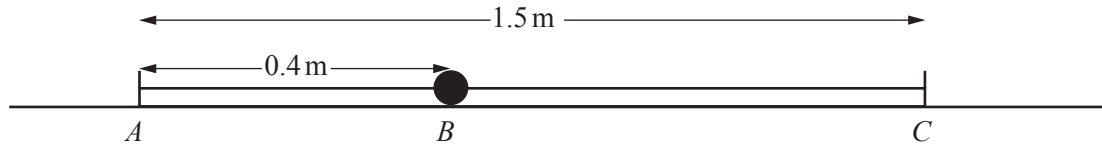
Two uniform smooth spheres A and B , of equal radius, have masses $2m\text{ kg}$ and $3m\text{ kg}$ respectively. The spheres are approaching each other on a horizontal surface when they collide. Before the collision A is moving with speed 5 ms^{-1} in a direction making an angle α with the line of centres, where $\cos \alpha = \frac{4}{5}$, and B is moving with speed $3\frac{1}{4}\text{ ms}^{-1}$ in a direction making an angle β with the line of centres, where $\cos \beta = \frac{5}{13}$. A straight vertical wall is situated to the right of B , perpendicular to the line of centres (see diagram). The coefficient of restitution between A and B is $\frac{2}{3}$.

- (i) Find the speed of A after the collision. Find also the component of the velocity of B along the line of centres after the collision. [7]

B subsequently hits the wall.

- (ii) Explain why A and B will have a second collision if the coefficient of restitution between B and the wall is sufficiently large. Find the set of values of the coefficient of restitution for which this second collision will occur. [3]

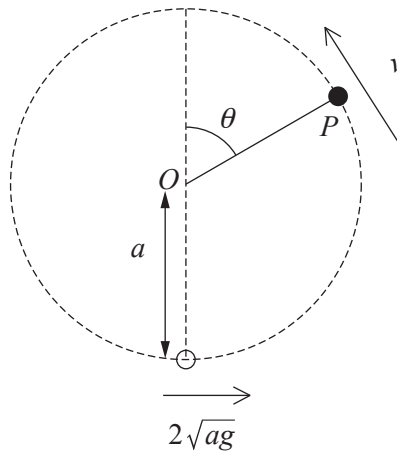
4



A and C are two fixed points, 1.5 m apart, on a smooth horizontal plane. A light elastic string of natural length 0.4 m and modulus of elasticity 20 N has one end fixed to point A and the other end fixed to a particle B . Another light elastic string of natural length 0.6 m and modulus of elasticity 15 N has one end fixed to point C and the other end fixed to the particle B . The particle is released from rest when ABC forms a straight line and $AB = 0.4$ m (see diagram).

Find the greatest kinetic energy of particle B in the subsequent motion. [7]

5



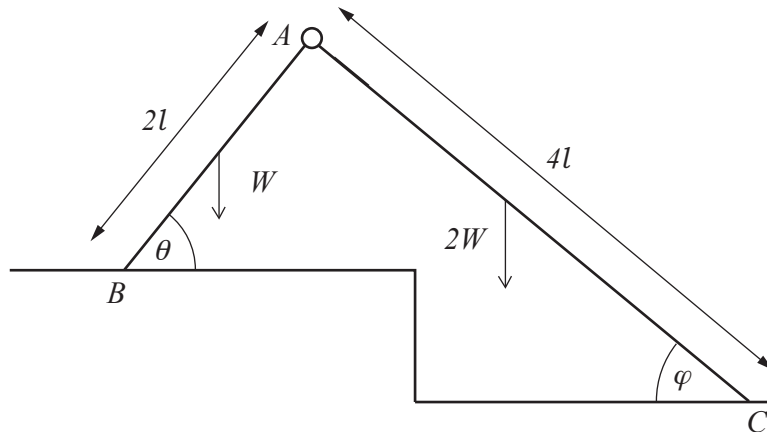
One end of a light inextensible string of length a is attached to a fixed point O . A particle P of mass m is attached to the other end of the string and hangs at rest. P is then projected horizontally from this position with speed $2\sqrt{ag}$. When the string makes an angle θ with the upward vertical P has speed v (see diagram). The tension in the string is T .

- (i) Find an expression for T in terms of m , g and θ , and hence find the height of P above its initial level when the string becomes slack. [6]

P is now projected horizontally from the same initial position with speed U .

- (ii) Find the set of values of U for which the string does not remain taut in the subsequent motion. [5]

6



Two uniform rods AB and AC are freely jointed at A . Rod AB is of length $2l$ and weight W ; rod AC is of length $4l$ and weight $2W$. The rods rest in equilibrium in a vertical plane on two rough horizontal steps, so that AB makes an angle of θ with the horizontal, where $\sin \theta = \frac{4}{5}$, and AC makes an angle of φ with the horizontal, where $\sin \varphi = \frac{3}{5}$ (see diagram). The force of the step acting on AB at B has vertical component R and horizontal component F .

(i) By taking moments about A for the rod AB , find an equation relating W , R and F . [3]

(ii) Show that $R = \frac{73}{50}W$, and find the vertical component of the force acting on AC at C . [6]

(iii) The coefficient of friction at B is equal to that at C . Given that one of the rods is on the point of slipping, explain which rod this must be, and find the coefficient of friction. [4]

7 A particle P of mass m kg is attached to one end of a light elastic string of modulus of elasticity $24mg$ N and natural length 0.6 m. The other end of the string is attached to a fixed point O ; the particle P rests in equilibrium at a point A with the string vertical.

(i) Show that the distance OA is 0.625 m. [2]

Another particle Q , of mass $3m$ kg, is released from rest from a point 0.4 m above P and falls onto P . The two particles coalesce.

(ii) Show that the combined particle initially moves with speed 2.1 m s^{-1} . [3]

(iii) Show that the combined particle initially performs simple harmonic motion, and find the centre of this motion and its amplitude. [5]

(iv) Find the time that elapses between Q being released from rest and the combined particle first reaching the highest point of its subsequent motion. [7]

END OF QUESTION PAPER

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