

Take $g = 9.8 \text{ ms}^{-2}$ and give all answers correct to 3 significant figures where necessary.

1. A constant force acts on a particle of mass 200 grams, moving it 50 cm in a straight line on a rough horizontal surface at a constant speed. The coefficient of friction between the particle and the surface is $\frac{1}{4}$.
Calculate, in J, the work done by the force. (4 marks)

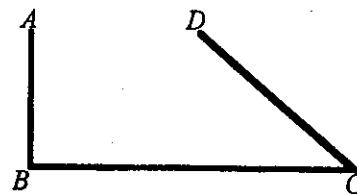
2. A stone, of mass 0.9 kg, is projected vertically upwards with speed 10 ms^{-1} in a medium which exerts a constant resistance to motion. It comes to rest after rising a distance of 3.75 m. Find the magnitude of the non-gravitational resisting force acting on the stone. (5 marks)

3. A particle P , of mass 0.4 kg, moves in a straight line such that, at time t seconds after passing through a fixed point O , its distance from O is x metres, where $x = 3t^2 + 8t$.
 - (a) Show that P never returns to O . (2 marks)
 - (b) Find the value of t when P has velocity 20 ms^{-1} . (3 marks)
 - (c) Show that the force acting on P is constant, and find its magnitude. (3 marks)

4. Two smooth spheres A and B , of masses $2m$ and $3m$ respectively, are moving on a smooth horizontal table with velocities $(3\mathbf{i} - \mathbf{j}) \text{ ms}^{-1}$ and $(4\mathbf{i} + \mathbf{j}) \text{ ms}^{-1}$, where \mathbf{i} and \mathbf{j} are perpendicular unit vectors. They collide, after which A has velocity $(5\mathbf{i} + \mathbf{j}) \text{ ms}^{-1}$.
 - (a) Find the magnitude of the impulse exerted on B by A , stating the units of your answer. (4 marks)
 - (b) Find the speed of B immediately after the collision. (5 marks)

5. A small car, of mass 850 kg, moves on a straight horizontal road. Its engine is working at its maximum rate of 25 kW, and a constant resisting force of magnitude 900 N opposes the car's motion.
 - (a) Find the acceleration of the car when it is moving with speed 15 ms^{-1} . (3 marks)
 - (b) Find the maximum speed of the car on the horizontal road. (3 marks)With the engine still working at 25 kW and the non-gravitational resistance remaining at 900 N, the car now climbs a hill inclined at an angle α to the horizontal, where $\sin \alpha = \frac{1}{10}$.
 - (c) Find the maximum speed of the car on this hill. (4 marks)

6. A uniform wire $ABCD$ is bent into the shape shown, where the sections AB , BC and CD are straight and of length $3a$, $10a$ and $5a$ respectively and AD is parallel to BC .



- (a) Show that the cosine of angle BCD is $\frac{4}{5}$. (2 marks)
 (b) Find the distances of the centre of mass of the bent wire from (i) AB , (ii) BC . (6 marks)

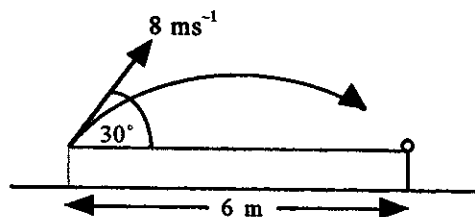
The wire is hung over a smooth peg at B and rests in equilibrium.

- (c) Find, to the nearest 0.1° , the angle between BC and the vertical in this position. (4 marks)

7. Two particles P and Q , of masses 0.3 kg and 0.2 kg respectively, are moving towards each other along a straight line. P has speed 4 ms^{-1} . They collide directly. After the collision the direction of motion of both particles has been reversed, and Q has speed 2 ms^{-1} . The coefficient of restitution between P and Q is $\frac{1}{3}$. Find

- (a) the speed of Q before the collision, (4 marks)
 (b) the speed of P after the collision, (4 marks)
 (c) the kinetic energy, in J, lost in the impact. (4 marks)

8. In a fairground game, a contestant bowls a ball at a coconut 6 metres away on the same horizontal level. The ball is thrown with an initial speed of 8 ms^{-1} in a direction making an angle of 30° with the horizontal.



- (a) Find the time taken by the ball to travel 6 m horizontally. (2 marks)
 (b) Showing your method clearly, decide whether or not the ball will hit the coconut. (4 marks)
 (c) Find the greatest height reached by the ball above the level from which it was thrown. (4 marks)
 (d) Find the maximum horizontal distance from which it is possible to hit the coconut if the ball is thrown with the same initial speed of 8 m s^{-1} . (3 marks)
 (e) State two assumptions that you have made about the ball and the forces which act on it as it travels towards the coconut. (2 marks)