Take $g = 9{\cdot}8\ \text{ms}^{-2}$ 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.

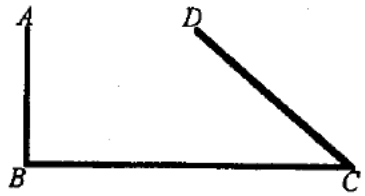
   (a) Find the acceleration of the car when it is moving with speed 15 ms^{-1}. **(3 marks)**

   (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)**

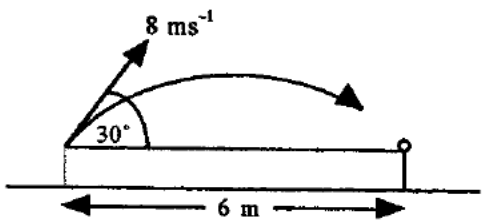
7. Two particles P and Q, of masses 0·3 kg and 0·2 kg respectively, are moving towards each other along a straight line. P has speed 4 ms^{-1}. They collide directly. After the collision the direction of motion of both particles has been reversed, and Q has speed 2 ms^{-1}. The coefficient of restitution 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)**