Take $g = 9{\cdot}8$ ms^{-2} and give all answers correct to 3 significant figures where necessary.

1. A car of mass 1200 kg decelerates from 30 ms^{-1} to 20 ms^{-1} in 6 seconds at a constant rate.

   (a) Find the magnitude, in N, of the decelerating force. **(2 marks)**

   (b) Find the loss, in J, in the car's kinetic energy. **(2 marks)**

2. A particle moves in a straight line from A to B in 5 seconds. At time t seconds after leaving A, the velocity of the particle is $(32t - 3t^2)$ ms^{-1}.

   (a) Calculate the straight-line distance AB. **(4 marks)**

   (b) Find the acceleration of the particle when $t = 3$. **(3 marks)**

3. Eddie, whose mass is 71 kg, rides a bicycle of mass 25 kg up a hill inclined at an angle α to the horizontal, where $\sin \alpha = \frac{1}{12}$. When Eddie is working at a rate of 600 W, he is moving at a constant speed of 6 ms^{-1}.

   Find the magnitude of the non-gravitational resistance to his motion. **(7 marks)**

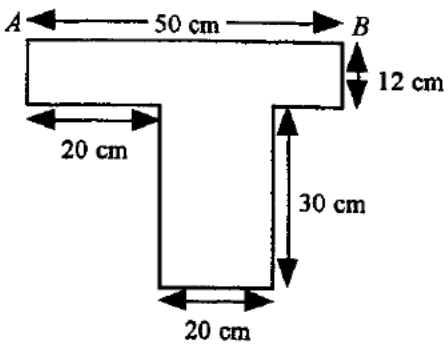
4. A boat leaves the point O and moves such that, t seconds later, its position vector relative to O is $(t^2 - 2)\,\mathbf{i} + 2t\,\mathbf{j}$, where the vectors $\mathbf{i}$ and $\mathbf{j}$ both have magnitude 1 metre and are directed parallel and perpendicular to the shoreline through O.

   (a) Find the speed with which the boat leaves O. **(3 marks)**

   (b) Show that the boat has constant acceleration and state the magnitude of this acceleration. **(2 marks)**

   (c) Find the value of t when the boat is 40 m from O. **(4 marks)**

   (d) Comment on the limitations of the given model of the boat's motion. **(1 mark)**

5. 

   The diagram shows a body which may be modelled as a uniform lamina.

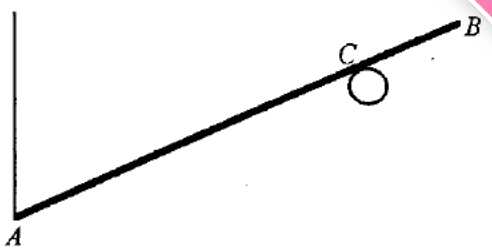
   The body is suspended from the point marked A and rests in equilibrium.

   (a) Calculate, to the nearest degree, the angle which the edge AB then makes with the vertical. **(8 marks)**

   Frank suggests that the angle between AB and the vertical would be smaller if the lamina were made from lighter material.

   (b) State, with a brief explanation, whether Frank is correct. **(2 marks)**

6. A uniform rod AB, of mass 0·8 kg and length $10a$, is supported at the end A by a light inextensible vertical string and rests in limiting equilibrium on a rough fixed peg at C, where $AC = 7a$.



(a) Draw a diagram to show all the forces acting on the rod. **(2 marks)**

(b) Find the magnitude of the tension in the string. **(4 marks)**

Given further that AB makes an angle of 20° with the horizontal,

(c) find the magnitude of the normal reaction exerted by the peg on the rod at C. **(4 marks)**

7. Two particles A and B, of mass m and km respectively, are moving in the same direction on a smooth horizontal surface. A has speed $4u$ and B has speed u. The coefficient of restitution between A and B is e. A collides directly with B, and in the collision the direction of A's motion is reversed. Immediately after the impact, B has speed $2u$.

(a) Show that the speed of A immediately after the impact is $u(3e - 2)$. **(4 marks)**

(b) Deduce the range of possible values of e. **(3 marks)**

(c) Show that $4 < k \leq 5$. **(6 marks)**

8. A ball is projected from ground level with speed 34 ms^{-1} at an angle α above the horizontal, where $\tan \alpha = \frac{8}{15}$.

(a) Find the greatest height reached by the ball above ground level. **(5 marks)**

While it is descending, the ball hits a horizontal ledge 6 metres above ground level.

(b) Find the horizontal distance travelled by the ball before it hits the ledge. **(6 marks)**

(c) Find the speed of the ball at the instant when it hits the ledge. **(3 marks)**