

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

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

 - Find the magnitude, in N , of the decelerating force. (2 marks)
 - Find the loss, in J , in the car's kinetic energy. (2 marks)

- 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 $(32t - 3t^2) \text{ ms}^{-1}$.

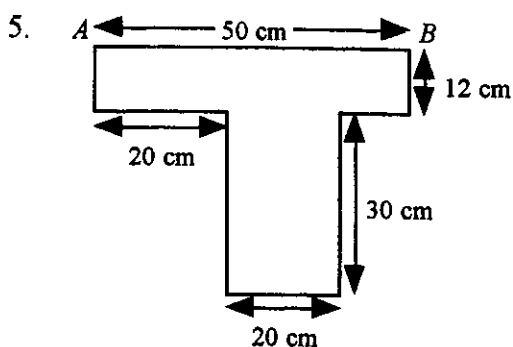
 - Calculate the straight-line distance AB . (4 marks)
 - Find the acceleration of the particle when $t = 3$. (3 marks)

- 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)

- 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 .

 - Find the speed with which the boat leaves O . (3 marks)
 - Show that the boat has constant acceleration and state the magnitude of this acceleration. (2 marks)
 - Find the value of t when the boat is 40 m from O . (4 marks)
 - Comment on the limitations of the given model of the boat's motion. (1 mark)



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

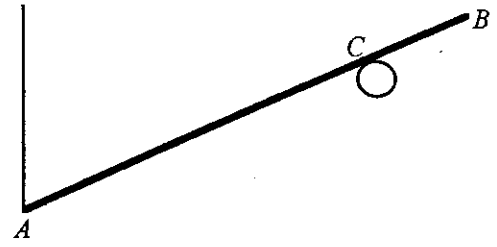
The body is suspended from the point marked A and rests in equilibrium.

- 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.

- 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)**