OCR
Oxford Cambridge and RSA

A Level Mathematics B (MEI)

H640/01 MEI Pure Mathematics and Mechanics

Mechanics

Question Set 6

1 Rory pushes a box of mass 2.8 kg across a rough horizontal floor against a resistance of 19 N. Rory applies a constant horizontal force. The box accelerates from rest to $1.2\,\text{m s}^{-1}$ as it travels 1.8 m.

(a) Calculate the acceleration of the box. **[2]**

(b) Find the magnitude of the force that Rory applies. **[2]**

2 The position vector **r** metres of a particle at time t seconds is given by

$$\mathbf{r} = (1 + 12t - 2t^2)\mathbf{i} + (t^2 - 6t)\mathbf{j}.$$

(a) Find an expression for the velocity of the particle at time t. **[2]**

(b) Determine whether the particle is ever stationary. **[2]**

3 A rod of length 2 m hangs vertically in equilibrium. Parallel horizontal forces of 30 N and 50 N are applied to the top and bottom and the rod is held in place by a horizontal force F N applied x m below the top of the rod as shown in Fig. 3.

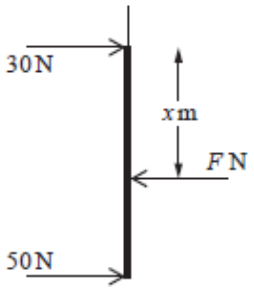


Fig. 3

(a) Find the value of F. **[1]**

(b) Find the value of x. **[2]**

4 A pebble is thrown horizontally at $14\,\text{m s}^{-1}$ from a window which is 5 m above horizontal ground. The pebble goes over a fence 2 m high d m away from the window as shown in Fig. 4. The origin is on the ground directly below the window with the x-axis horizontal in the direction in which the pebble is thrown and the y-axis vertically upwards.

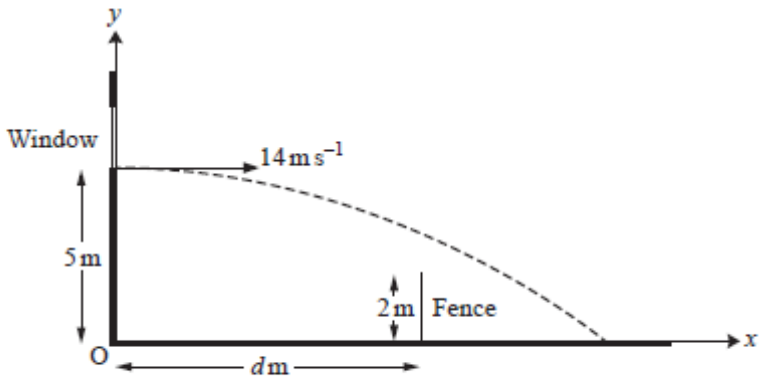


Fig. 4

(a) Find the time the pebble takes to reach the ground. **[3]**

(b) Find the cartesian equation of the trajectory of the pebble. **[4]**

(c) Find the range of possible values for d. **[3]**

5 Fig. 5 shows two blocks at rest, connected by a light inextensible string which passes over a smooth pulley. Block A of mass 4.7 kg rests on a smooth plane inclined at 60° to the horizontal. Block B of mass 4 kg rests on a rough plane inclined at 25° to the horizontal. On either side of the pulley, the string is parallel to a line of greatest slope of the plane. Block B is on the point of sliding up the plane.

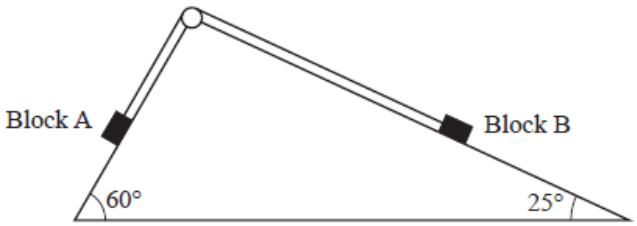


Fig. 5

(a) Show that the tension in the string is 39.9 N correct to 3 significant figures. **[2]**

(b) Find the coefficient of friction between the rough plane and Block B. **[5]**

6 The velocity of a car, $v\,\text{m s}^{-1}$ at time t seconds, is being modelled. Initially the car has velocity $5\,\text{m s}^{-1}$ and it accelerates to $11.4\,\text{m s}^{-1}$ in 4 seconds.

In model A, the acceleration is assumed to be uniform.

(a) Find an expression for the velocity of the car at time t using this model. **[3]**

(b) Explain why this model is not appropriate in the long term. **[1]**

Model A is refined so that the velocity remains constant once the car reaches $17.8\,\text{m s}^{-1}$.

(c) Sketch a velocity-time graph for the motion of the car, making clear the time at which the acceleration changes. **[3]**

(d) Calculate the displacement of the car in the first 20 seconds according to this refined model. **[3]**

In model B, the velocity of the car is given by

$$v = \begin{cases} 5 + 0.6t^2 - 0.05t^3 & \text{for } 0 \leqslant t \leqslant 8, \\ 17.8 & \text{for } 8 < t \leqslant 20. \end{cases}$$

(e) Show that this model gives an appropriate value for v when $t = 4$. **[1]**

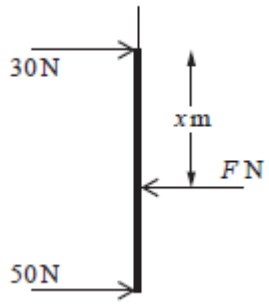
(f) Explain why the value of the acceleration immediately before the velocity becomes constant is likely to mean that model B is a better model than model A. **[3]**

(g) Show that model B gives the same value as model A for the displacement at time 20 s. **[3]**

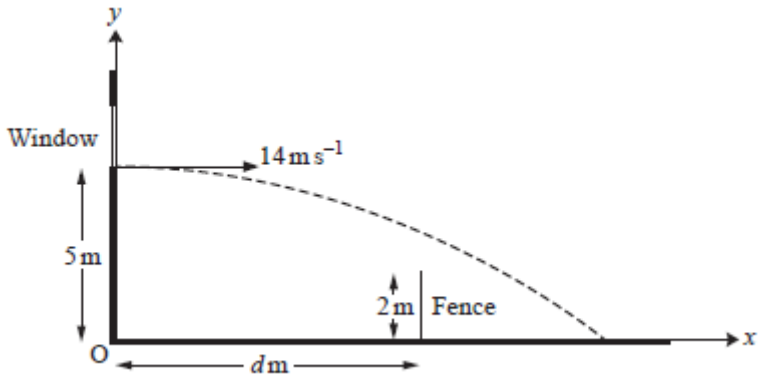
Total Marks for Question Set 6: 45

Resource Materials

Question Set No: 6 Fig. 3



Question Set No: 6 Fig. 4



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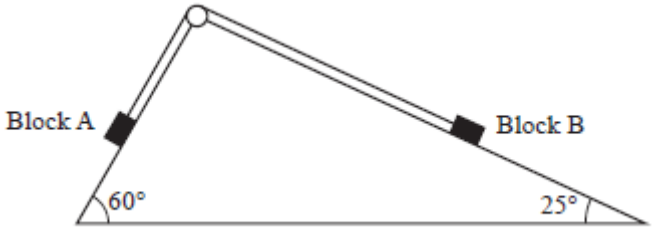

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