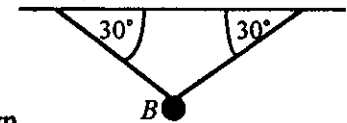


Take  $g = 9.8 \text{ ms}^{-2}$  and give all answers correct to 3 significant figures where necessary.

1. A bee flies in a straight line from  $A$  to  $B$ , where  $\vec{AB} = (3\frac{1}{2}\mathbf{i} - 12\mathbf{j}) \text{ m}$ , in 5 seconds at a constant speed. Find
- (a) the straight-line distance  $AB$ , (2 marks)
  - (b) the speed of the bee, (2 marks)
  - (c) the velocity vector of the bee. (2 marks)

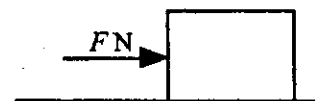
2. A small ball  $B$ , of mass  $0.8 \text{ kg}$ , is suspended from a horizontal ceiling by two light inextensible strings.  $B$  is in equilibrium under gravity with both strings inclined at  $30^\circ$  to the horizontal, as shown.



- (a) Find the tension, in N, in either string. (3 marks)
- (b) Calculate the magnitude of the least horizontal force that must be applied to  $B$  in this position to cause one string to become slack. (4 marks)

3. A particle  $P$  moves in a straight line through a fixed point  $O$  with constant acceleration  $a \text{ ms}^{-2}$ . 3 seconds after passing through  $O$ ,  $P$  is 6 m from  $O$ . After a further 6 seconds,  $P$  has travelled a further 33 m in the same direction. Calculate
- (a) the value of  $a$ , (5 marks)
  - (b) the speed with which  $P$  passed through  $O$ . (2 marks)

4. A force of magnitude  $F \text{ N}$  is applied to a block of mass  $M \text{ kg}$  which is initially at rest on a horizontal plane. The block starts to move with acceleration  $3 \text{ ms}^{-2}$ . Modelling the block as a particle,

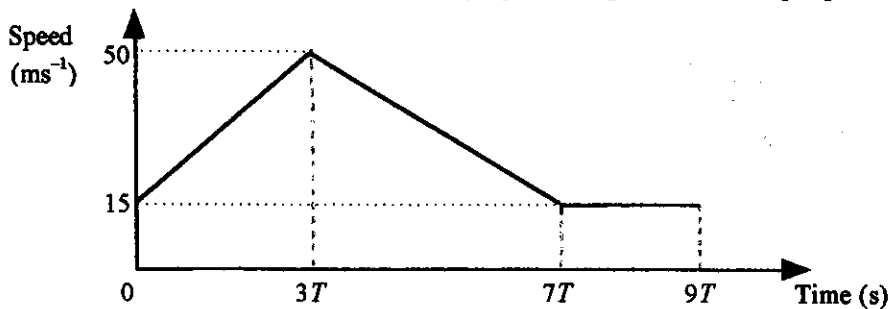


- (a) if the plane is smooth, find an expression for  $F$  in terms of  $M$ . (2 marks)
- If the plane is rough, and the coefficient of friction between the block and the plane is  $\mu$ ,
- (b) express  $F$  in terms of  $M$ ,  $\mu$  and  $g$ . (2 marks)
- (c) Calculate the value of  $\mu$  if  $F = \frac{1}{2}Mg$ . (3 marks)

5. Two metal weights  $A$  and  $B$ , of masses  $2.4 \text{ kg}$  and  $1.8 \text{ kg}$  respectively, are attached to the ends of a light inextensible string which passes over a smooth fixed pulley so that the string hangs vertically on each side. The system is released from rest with the string taut.
- (a) Calculate the acceleration of each weight and the tension in the string. (6 marks)
  - $A$  is now replaced by a different weight of mass  $m \text{ kg}$ , where  $m < 1.8$ , and the system is again released from rest. The magnitude of the acceleration has half of its previous value.
  - (b) Calculate the value of  $m$ . (6 marks)

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6. The diagram shows the speed-time graph for a particle during a period of  $9T$  seconds.



- (a) If  $T = 5$ , find
  - (i) the acceleration for each section of the motion, (2 marks)
  - (ii) the total distance travelled by the particle. (2 marks)
- (b) Sketch, for this motion, (i) an acceleration-time graph, (2 marks)  
 (ii) a displacement-time graph. (2 marks)
- (c) Calculate the value of  $T$  for which the distance travelled over the  $9T$  seconds is  $3.708$  km. (4 marks)

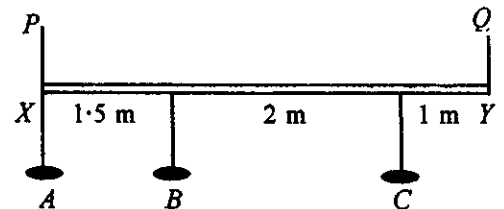
7. Two smooth spheres  $A$  and  $B$ , of masses  $60$  grams and  $90$  grams respectively, are at rest on a smooth horizontal table.  $A$  is projected towards  $B$  with speed  $4 \text{ ms}^{-1}$  and the particles collide. After the collision,  $A$  and  $B$  move in the same direction as each other, with speeds  $u \text{ ms}^{-1}$  and  $6u \text{ ms}^{-1}$  respectively. Calculate

- (a) the value of  $u$ , (4 marks)
- (b) the magnitude of the impulse exerted by  $A$  on  $B$ , stating the units of your answer. (3 marks)

$A$  and  $B$  are now replaced in their original positions and projected towards each other with speeds  $2 \text{ ms}^{-1}$  and  $8 \text{ ms}^{-1}$  respectively. They collide again, after which  $A$  moves with speed  $7 \text{ ms}^{-1}$ , its direction of motion being reversed.

- (c) Find the speed of  $B$  after this collision and state whether its direction of motion has been reversed. (5 marks)

8. In a theatre, three lights  $A$ ,  $B$  and  $C$  are suspended from a horizontal beam  $XY$  of length  $4.5$  m.  $A$  and  $C$  are each of mass  $8$  kg and  $B$  is of mass  $6$  kg. The beam  $XY$  is held in place by vertical ropes  $PX$  and  $QY$ , as shown.



In a simple mathematical model of this situation,  $XY$  is modelled as a light rod.

- (a) Calculate the tension in each of  $PX$  and  $QY$ . (6 marks)

In a refined model,  $XY$  is modelled as a uniform rod of mass  $m$  kg.

- (b) If the tension in  $PX$  is  $1.5$  times that in  $QY$ , calculate the value of  $m$ . (6 marks)