

Solomon Practice Paper

Mechanics 2D

Time allowed: 90 minutes

Centre:

Name:

Teacher:

Question	Points	Score
1	6	
2	6	
3	10	
4	12	
5	13	
6	14	
7	14	
Total:	75	



1. A particle P moves such that at time t seconds its position vector, r metres, relative to a fixed origin O is given by

$$\mathbf{r} = \left(\frac{3}{2}t^2 - 3t\right)\mathbf{i} + \left(\frac{1}{3}t^3 - kt\right)\mathbf{j},$$

where k is a constant and \mathbf{i} and \mathbf{j} are perpendicular horizontal unit vectors.

- (a) Find an expression for the velocity of P at time t . [3]
 (b) Given that P comes to rest instantaneously, find the value of k . [3]

Total: 6

2. Two smooth spheres P and Q of equal radius and of mass $2m$ and $5m$ respectively, are moving towards each other along a horizontal straight line when they collide. After the collision, P and Q travel in opposite directions with speeds of 3 ms^{-1} and 4 ms^{-1} respectively. [6]

Given that the coefficient of restitution between the two particles is $\frac{1}{2}$, find the speeds of P and Q before the collision.

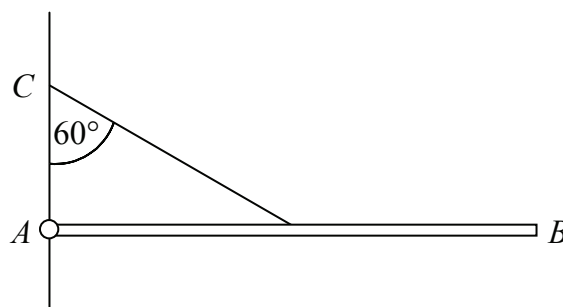
3. A car of mass 1200kg experiences a resistance to motion, R newtons, which is proportional to its speed, $v \text{ ms}^{-1}$. When the power output of the car engine is 90 kW and the car is travelling along a horizontal road, its maximum speed is 50 ms^{-1} . [4]
 (a) Show that $R = 36v$.

The car ascends a hill inclined at an angle θ to the horizontal where $\sin \theta = \frac{1}{14}$.

- (b) Find, correct to 3 significant figures, the maximum speed of the car up the hill assuming that the power output of the engine is unchanged. [6]

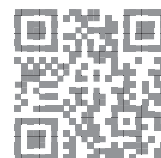
Total: 10

4. Figure shows a uniform rod AB of mass 2kg and length $2a$.



The end A is attached by a smooth hinge to a fixed point on a vertical wall so that the rod can rotate freely in a vertical plane. A mass of 6kg is placed at B and the rod is held in a horizontal position by a light string joining the midpoint of the rod to a point C on the wall, vertically above A . The string is inclined at an angle of 60° to the wall.

- (a) Show that the tension in the string is $28g$. [4]
 (b) Find the magnitude and direction of the force exerted by the hinge on the rod, giving your answers correct to 3 significant figures. [8]



Total: 12

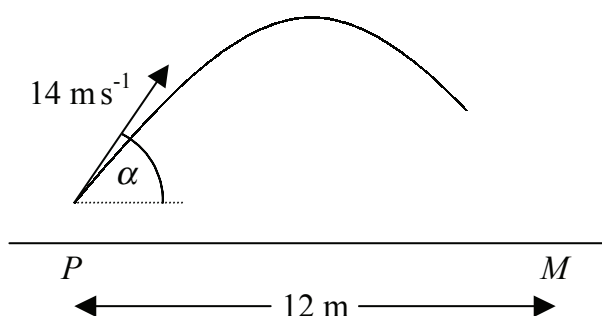
5. A particle P moves in a straight line with an acceleration of $(6t - 10) \text{ ms}^{-2}$ at time t seconds. Initially P is at O , a fixed point on the line, and has velocity 3 ms^{-1} .

(a) Find the values of t for which the velocity of P is zero. [6]

(b) Show that, during the first two seconds, P travels a distance of $6\frac{26}{27}\text{m}$. [7]

Total: 13

6. A football player strikes a ball giving it an initial speed of 14 ms^{-1} at an angle α to the horizontal as shown in Figure.



At the instant he strikes the ball it is 0.6 m vertically above the point P on the ground. The trajectory of the ball is in a vertical plane containing P and M , the middle of the goal-line. The distance between P and M is 12 m and the ground is horizontal.

Given that the ball passes over the point M without bouncing,

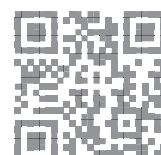
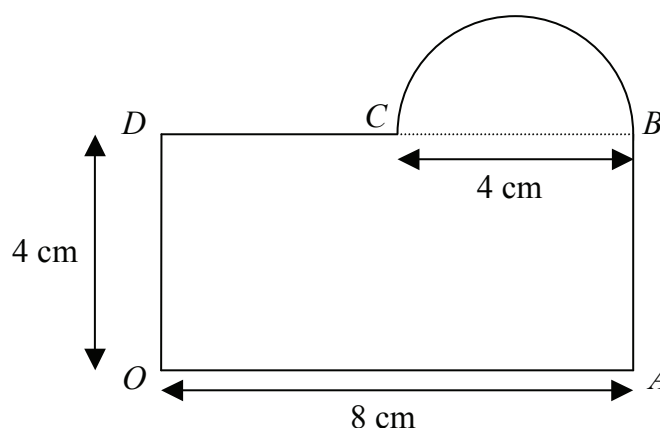
(a) find, to the nearest degree, the minimum value of α . [8]

Given that the crossbar of the goal is 2.4 m above M and that $\tan \alpha = \frac{4}{3}$,

(b) show that the ball passes 4.2m vertically above the crossbar. [6]

Total: 14

7. Figure shows a hotel ‘key’ consisting of a rectangle $OABD$, where $OA = 8 \text{ cm}$ and $OD = 4 \text{ cm}$, joined to a semicircle whose diameter BC is 4 cm long.



The thickness of the key is negligible and the same material is used throughout.

The key is modelled as a uniform lamina.

Using this model,

(a) find, correct to 3 significant figures, the distance of the centre of mass from [10]

A small circular hole of negligible diameter is made at the mid-point of BC so that the key can be hung on a smooth peg. When the key is freely suspended from the peg,

(b) find, correct to 3 significant figures, the acute angle made by OA with the vertical. [4]

Total: 14

