Solomon Practice Paper

Mechanics 2D

Time allowed: 90 **minutes**

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

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Teacher:

How I can achieve better:

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Last updated: July 14, 2025

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

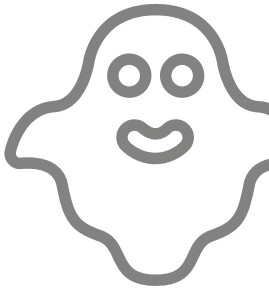
$$\mathbf{r} = \left(\frac{3}{2}t^2 - 3t\right)\mathbf{i} + \left(\frac{1}{3}t^3 - kt\right)\mathbf{j},$$

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]

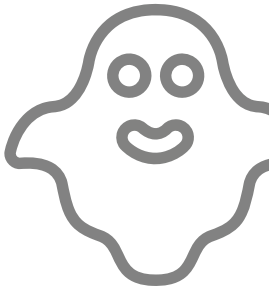
(b) Given that P comes to rest instantaneously, find the value of k. [3]

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.



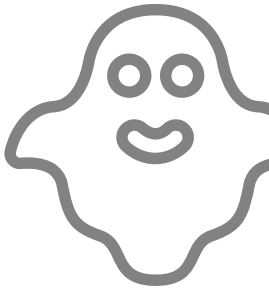
3. A car of mass 1200kg experiences a resistance to motion, R newtons, which is proportional to its speed, v ms^{-1}. When the power output of the car engine is 90 kW and the car is travelling along a horizontal road, its maximum speed is 50 ms^{-1}.

   (a) Show that $R = 36v$. [4]

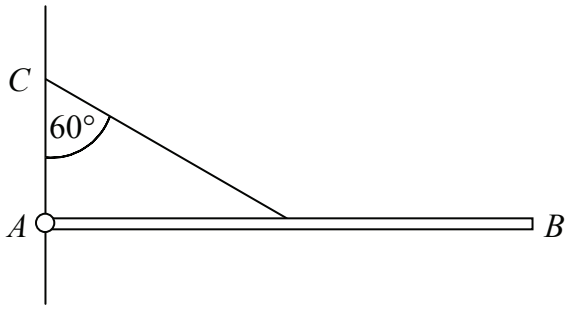
   The car ascends a hill inclined at an angle θ to the horizontal where $\sin\theta = \frac{1}{14}$.

   (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]

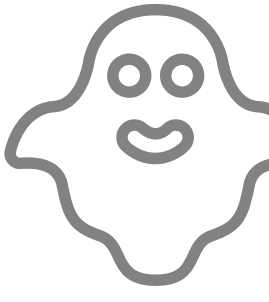
Total: 12

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

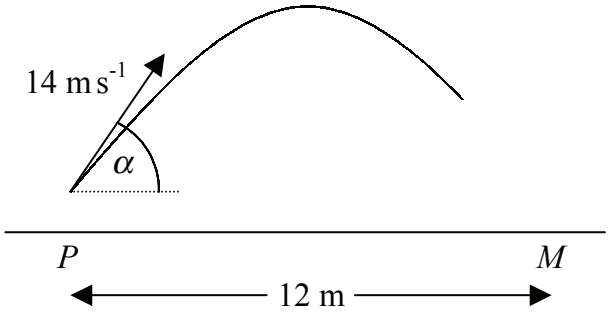
   (a) Find the values of t for which the velocity of P is zero. [6]

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

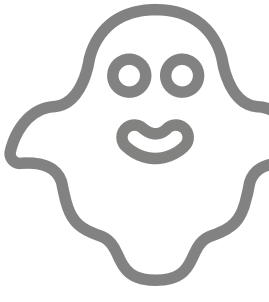
Given that the ball passes over the point M without bouncing,

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

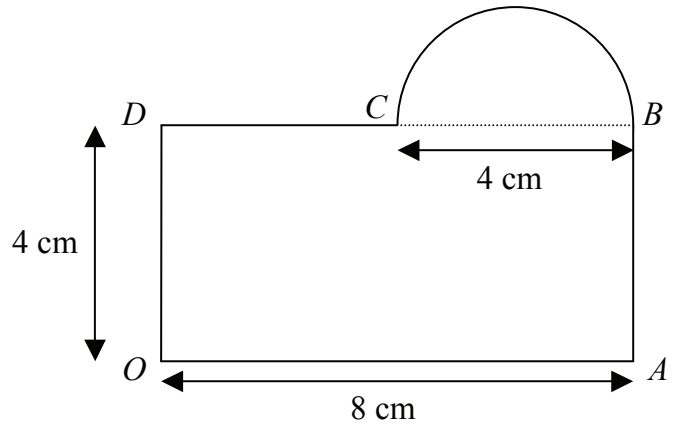
Given that the crossbar of the goal is 2.4 m above M and that $\tan\alpha = \frac{4}{3}$,

(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 $OA = 8$ cm and $OD = 4$ 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