Solomon Practice Paper

Mechanics 1D

Time allowed: 90 **minutes**

Question	Points	Score
1	5	
2	6	
3	7	
4	10	
5	10	
6	11	
7	12	
8	14	
Total:	75	

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BY NC ND

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1. A particle, P, of mass 5kg moves with speed 3 ms^{-1} along a smooth horizontal track. It strikes a particle Q of mass 2kg which is at rest on the track. Immediately after the collision, P and Q move in the same direction with speeds v and $2v$ ms^{-1} respectively.

   (a) Calculate the value of v. [3]

   (b) Calculate the magnitude of the impulse received by Q on impact. [2]

Total: 5

2. A particle P moves with a constant velocity $(3\mathbf{i} + 2\mathbf{j})$ ms^{-1} with respect to a fixed origin O. It passes through the point A whose position vector is $(2\mathbf{i} + 11\mathbf{j})$m at $t = 0$.

   (a) Find the angle in degrees that the velocity vector of P makes with the vector $\mathbf{i}$. [2]

   (b) Calculate the distance of P from O when $t = 2$. [4]

Total: 6

3. A car of mass 1250kg is moving at constant speed up a hill, inclined at an angle α to the horizontal, where $\sin(\alpha) = \frac{1}{10}$. The driving force produced by the engine is 1800N.

   (a) Calculate the resistance to motion which the car experiences. [4]

   At the top of the hill, the road becomes horizontal.

   (b) Find the initial acceleration of the car. [3]

Total: 7

4. A non-uniform plank AB of mass 20kg and length 6m is supported at both ends so that it is horizontal. When a woman of mass 60kg stands on the plank at a distance of 2m from B, the magnitude of the reaction at A is $35g$N.

   (a) Suggest a suitable model for [2]

      i. the plank,

      ii. the woman.

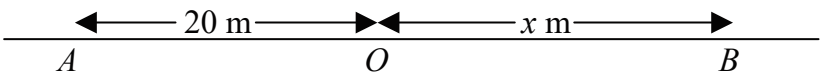
   (b) Calculate the magnitude of the reaction at B, giving your answer in terms of g. [2]

   (c) Explain briefly, in the context of the problem, the term 'non-uniform'. [2]

   (d) Find the distance of the centre of mass of the plank from A. [4]

Total: 10

5. The points A, O and B lie on a straight horizontal track as shown in Figure. A is 20m from O and B is on the other side of O at a distance xm from O. [10]



At time $t = 0$, a particle P starts from rest at O and moves towards B with uniform acceleration of 3 ms^{-2}. At the same instant, another particle Q, which is at the point A, is moving with a velocity of 3 ms^{-1} in the direction of O with uniform acceleration of 4 ms^{-2} in the same direction.

Given that the Q collides with P at B, find the value of x.

6. A sledge of mass 4kg rests in limiting equilibrium on a rough slope inclined at an angle 10° to the horizontal. By modelling the sledge as a particle,

   (a) show that the coefficient of friction, μ, between the sledge and the ground is 0.176 correct to 3 significant figures. [6]

   The sledge is placed on a steeper part of the slope which is inclined at an angle 30° to the horizontal. The value of μ remains unchanged.

   (b) Find the minimum extra force required along the line of greatest slope to prevent the sledge from slipping down the hill. [5]

Total: 11

7. Whilst looking over the edge of a vertical cliff, 122.5 metres in height, Jim dislodges a stone. The stone falls freely from rest towards the sea below.

   Ignoring the effect of air resistance,

   (a) calculate the time it would take for the stone to reach the sea, [3]

   (b) find the speed with which the stone would hit the water. [2]

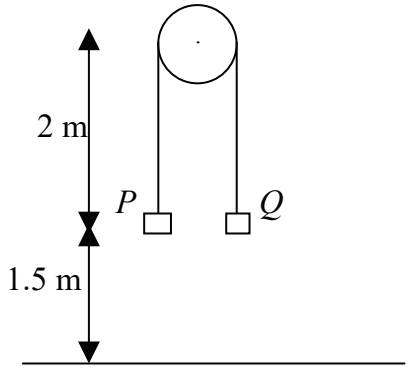
   Two seconds after the stone begins to fall, Jim throws a tennis ball downwards at the stone. The tennis ball's initial speed is u ms^{-1} and it hits the stone before they both reach the water.

   (c) Find the minimum value of u. [5]

   (d) If you had taken air resistance into account in your calculations, what effect would this have had on your answer to part (c)? Explain your answer. [2]

Total: 12

8. Figure shows two particles P and Q, of mass 3kg and 2kg respectively, attached to the ends of a light, inextensible string which passes over a smooth, fixed pulley.



The system is released from rest with P and Q at the same level 1.5 metres above the ground and 2 metres below the pulley.

(a) Show that the initial acceleration of the system is $\frac{g}{5}$ ms^{-2}. [4]

(b) Find the tension in the string. [2]

(c) Find the speed with which P hits the ground. [3]

When P hits the ground, it does not rebound.

(d) What is the closest that Q gets to the pulley. [5]

Total: 14