

# Solomon Practice Paper

## Mechanics 2F

**Time allowed:** 90 minutes

**Centre:** [www.CasperYC.club](http://www.CasperYC.club)

**Name:**

**Teacher:**

Question	Points	Score
1	5	
2	8	
3	8	
4	9	
5	12	
6	16	
7	17	
Total:	75	

**How I can achieve better:**

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1. An ice hockey puck of mass  $0.5\text{kg}$  is moving with velocity  $(5\mathbf{i} - 8\mathbf{j}) \text{ ms}^{-1}$ , where  $\mathbf{i}$  and  $\mathbf{j}$  are perpendicular horizontal unit vectors, when it is struck by a stick. After the impact, the puck travels with velocity  $(13\mathbf{i} + 7\mathbf{j}) \text{ ms}^{-1}$ . [5]

Find the magnitude of the impulse exerted by the stick on the puck.



2. A car of mass 1 tonne is climbing a hill inclined at an angle  $\theta$  to the horizontal where  $\sin \theta = \frac{1}{7}$ . When the car passes a point  $X$  on the hill, it is travelling at  $20 \text{ ms}^{-1}$ . When the car passes the point  $Y$ , 200 m further up the hill, it has speed  $10 \text{ ms}^{-1}$ .

In a preliminary model of the situation, the car engine is assumed only to be doing work against gravity. Using this model,

- (a) find the change in the total mechanical energy of the car as it moves from  $X$  to  $Y$ . [6]

In a more sophisticated model, the car engine is also assumed to work against other forces.

- (b) Write down two other forces which this model might include. [2]

Total: 8



3. A particle moves along a straight horizontal track such that its displacement,  $s$  metres, from a fixed point  $O$  on the line after  $t$  seconds is given by

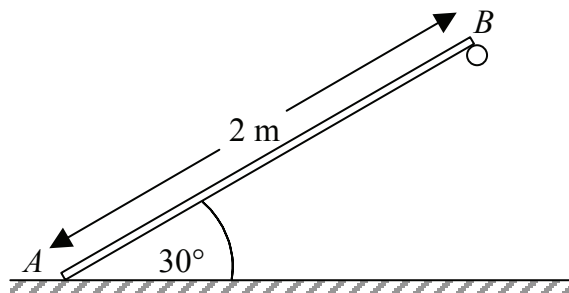
$$s = 2t^3 - 13t^2 + 20t.$$

- (a) Find the values of  $t$  for which the particle is at  $O$ . [4]
- (b) Find the values of  $t$  at which the particle comes instantaneously to rest. [4]

Total: 8



4. Figure shows a uniform rod  $AB$  of length 2 m and mass 6 kg inclined at an angle of  $30^\circ$  to the horizontal with  $A$  on smooth horizontal ground and  $B$  supported by a rough peg.



The rod is in limiting equilibrium and the coefficient of friction between  $B$  and the peg is  $\mu$ .

- (a) Find, in terms of  $g$ , the magnitude of the reactions at  $A$  and  $B$ .

[6]

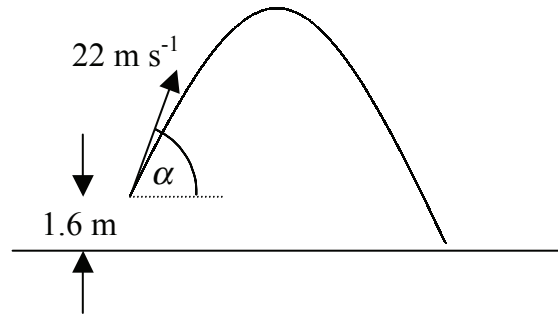
- (b) Show that  $\mu = \frac{1}{3}$ .

[3]

Total: 9



5. During a cricket match, a batsman hits the ball giving it an initial velocity of  $22 \text{ ms}^{-1}$  at an angle  $\alpha$  to the horizontal where  $\sin \alpha = \frac{7}{8}$ .



When the batsman strikes the ball it is 1.6 metres above the ground, as shown in Figure, and it subsequently moves freely under gravity.

- (a) Find, correct to 3 significant figures, the maximum height above the ground reached by the ball. [4]

The ball is caught by a fielder when it is 0.2 metres above the ground.

- (b) Find the length of time for which the ball is in the air. [4]

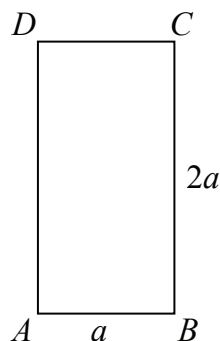
Assuming that the fielder who caught the ball ran at a constant speed of  $6 \text{ ms}^{-1}$ ,

- (c) find, correct to 3 significant figures, the maximum distance that the fielder could have been from the ball when it was struck. [4]

Total: 12



6. Figure shows a uniform rectangular lamina  $ABCD$  of mass  $8m$  in which the sides  $AB$  and  $BC$  are of length  $a$  and  $2a$  respectively.



Particles of mass  $2m$ ,  $6m$  and  $4m$  are fixed to the lamina at the points  $A$ ,  $B$  and  $D$  respectively.

- (a) Write down the distance of the centre of mass from  $AD$ . [1]  
 (b) Show that the distance of the centre of mass from  $AB$  is  $\frac{4}{5}a$ . [5]

Another particle of mass  $km$  is attached to the lamina at the point  $B$ .

- (c) Show that the distance of the centre of mass from  $AD$  is now given by  $\frac{(10+k)a}{20+k}$  [4]

Given that when the lamina is suspended freely from the point  $A$  the side  $AB$  makes an angle of  $45^\circ$  with the vertical,

- (d) find the value of  $k$ . [6]

Total: 16



7. Particle  $A$  of mass  $7\text{kg}$  is moving with speed  $u_1$  on a smooth horizontal surface when it collides directly with particle  $B$  of mass  $4\text{kg}$  moving in the same direction as  $A$  with speed  $u_2$ .

After the impact,  $A$  continues to move in the same direction but its speed has been halved. Given that the coefficient of restitution between the particles is  $e$ ,

(a) show that  $8u^2(e + 1) = u_1(8e - 3)$ . [7]

Given also that  $u_1 = 14 \text{ ms}^{-1}$  and  $u_2 = 3 \text{ ms}^{-1}$ ,

(b) find  $e$ , [3]

(c) show that the percentage of the kinetic energy of the particles lost as a result of the impact is  $9.6\%$ , correct to 2 significant figures. [7]

Total: 17

