Year 13 Mock Set#02
Mechanics Paper

- Advised to print in "A3-booklets", this will allow all questions to be on the left hand side.
- You can also print in A4, double-sided, and two staples on the left
- If instead you print in 2-in-1 settings, first print the second page up to the last page, then print the cover page separately (to allow all questions on the left)

This exam paper has 4 questions, for a total of 50 marks.

Question	Marks	Score
1	9	
2	12	
3	14	
4	15	
Total:	50	

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1. [*In this question* **i** *and* **j** *are horizontal unit vectors due east and north respectively.*]

A particle P of mass 0.5 kg is moving on a smooth horizontal plane.
The origin O is on the plane.
At time $t = 0$, P passes through O moving with velocity $(\mathbf{i} - \mathbf{j})$ ms^{-1} At time t seconds, the resultant horizontal force acting on P is

$$\Big((3t - 1)\mathbf{i} + 2\mathbf{j}\Big)\text{N}$$

(a) Find the velocity of P at $t = 2$

(5)

(b) Find the distance of P from O at $t = 2$

(4)

Question 1 continued

Question 1 continued

Question 1 continued

(Total for Question 1 is 9 marks)

2. A ladder AB, of weight W and length $2a$, has one end A resting on rough horizontal ground.

The other end B rests against a vertical wall.

A man, Jürgen Klopp, of weight $6W$, stands on the ladder at a point C

The coefficient of friction between the ladder and the ground is $\frac{1}{3}$

The ladder rests in limiting equilibrium at an angle θ to the ground, where $\tan\theta = \frac{12}{5}$

The ladder is modelled as a uniform rod which lies in a vertical plane perpendicular to the wall.

Mr Klopp is modelled as a particle and the vertical wall is modelled as smooth.

(a) Find, in terms of W, the magnitude of the normal reaction exerted by the wall on the ladder at B.

(4)

(b) Find the length AC.

(4)

(c) State the assumptions you have used to model

(i) the ladder as uniform,

(ii) the ladder as a rod.

(2)

In a refinement of the model, the vertical wall is considered to be rough. The ladder is still in limiting equilibrium.

(d) State, giving a reason, how this would affect your answer to part (a)

(2)

Question 2 continued

Question 2 continued

Question 2 continued

(Total for Question 2 is 12 marks)

3.

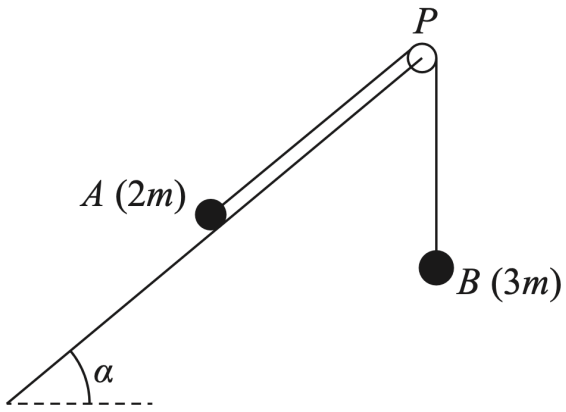

Figure 1

One end of a light inextensible string is attached to a particle A of mass $2m$. The other end of the string is attached to a particle B of mass $3m$. The string passes over a small, smooth, light pulley P which is fixed at the top of a rough inclined plane. The plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{3}{4}$

Particle A is held at rest on the plane with the string taut and B hanging freely below P, as shown in Figure 1. The section of the string AP is parallel to a line of greatest slope of the plane.

The coefficient of friction between A and the plane is $\frac{1}{2}$

Particle A is released and begins to move up the plane.

For the motion before A reaches the pulley,

(a) (i) write down an equation of motion for A,
(ii) write down an equation of motion for B,

(4)

(b) find, in terms of g, the acceleration of A,

(5)

(c) find the magnitude of the force exerted on the pulley by the string.

(4)

(d) State how you have used the information that P is a smooth pulley.

(1)

Question 3 continued

Question 3 continued

Question 3 continued

(Total for Question 3 is 14 marks)

4. *[In this question* **i** *and* **j** *are horizontal unit vectors due east and north respectively.]*

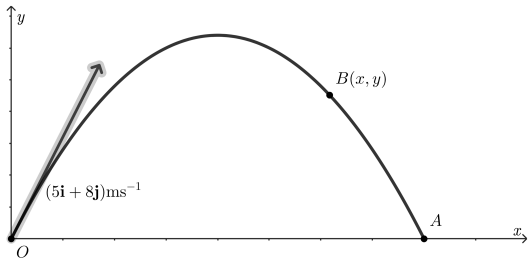

Figure 2

At time $t = 0$, a small ball B is projected from a fixed point O with velocity $(5\mathbf{i} + 8\mathbf{j})$ ms^{-1}.

The position vector of a point on the path of B is $(x\mathbf{i} + y\mathbf{j})$ m relative to O.

The ball is modelled as a particle moving freely under gravity.

The acceleration due to gravity is modelled as having magnitude 10 ms^{-2}.

The ball touched the ground at the point A, as shown in Figure 2.

(a) Show that

$$y = 1.6x - 0.2x^2$$

(4)

(b) Hence find the distance OA.

(2)

(c) Find the speed and the direction of motion of B as it passes through the point on the path where $x = 6$, giving your answer to 2 significant figures.

(6)

In reality, the acceleration due to gravity is less than 10 ms^{-2}

(d) State, giving a reason, how using a more accurate value for g would affect your answer to part (b).

(2)

(e) Suggest a possible improvement, apart from using a more accurate value for g, which could be made to the model.

(1)

Question 4 continued

Question 4 continued

Question 4 continued

Question 4 continued

Question 4 continued

Question 4 continued

(Total for Question 4 is 15 marks)

Total for paper is 50 marks