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| Please check the examination details below before entering your candidate information |  |                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                 |
| Candidate surname                                                                     |  | Other names                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                 |
| <b>Pearson Edexcel</b><br><b>Level 3 GCE</b>                                          |  | Centre Number                                                                                                                                                                                                                                                                           | Candidate Number                                                                                                                                                                                                                |
|                                                                                       |  | <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> | <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> <input style="width: 20px; height: 20px;" type="text"/> |
| <b>Friday 14 June 2019</b>                                                            |  |                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                 |
| Afternoon                                                                             |  | Paper Reference <b>9MA0-32</b>                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                 |
| <b>Mathematics</b><br><b>Advanced</b><br><b>Paper 32: Mechanics</b>                   |  |                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                 |
| <b>You must have:</b><br>Mathematical Formulae and Statistical Tables, calculator     |  |                                                                                                                                                                                                                                                                                         | Total Marks                                                                                                                                                                                                                     |

**Candidates may use any calculator allowed by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.**

#### Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams / sketches / graphs it must be dark (HB or B).
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided  
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear.  
Answers without working may not gain full credit.
- Answers should be given to three significant figures unless otherwise stated.

#### Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 5 questions in this question paper. The total mark for this paper is 50.
- The marks for **each** question are shown in brackets  
– *use this as a guide as to how much time to spend on each question.*

#### Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

**Answer ALL questions. Write your answers in the spaces provided.**

1. [In this question position vectors are given relative to a fixed origin  $O$ ]

At time  $t$  seconds, where  $t \geq 0$ , a particle,  $P$ , moves so that its velocity  $\mathbf{v}$  m s<sup>-1</sup> is given by

$$\mathbf{v} = 6t\mathbf{i} - 5t^{\frac{3}{2}}\mathbf{j}$$

When  $t = 0$ , the position vector of  $P$  is  $(-20\mathbf{i} + 20\mathbf{j})$  m.

- (a) Find the acceleration of  $P$  when  $t = 4$  (3)

- (b) Find the position vector of  $P$  when  $t = 4$  (3)

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(Total for Question 1 is 6 marks)

2. A particle,  $P$ , moves with constant acceleration  $(2\mathbf{i} - 3\mathbf{j})$  m s<sup>-2</sup>

At time  $t = 0$ , the particle is at the point  $A$  and is moving with velocity  $(-\mathbf{i} + 4\mathbf{j})$  m s<sup>-1</sup>

At time  $t = T$  seconds,  $P$  is moving in the direction of vector  $(3\mathbf{i} - 4\mathbf{j})$

- (a) Find the value of  $T$ . (4)

At time  $t = 4$  seconds,  $P$  is at the point  $B$ .

- (b) Find the distance  $AB$ . (4)

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(Total for Question 2 is 8 marks)

3.

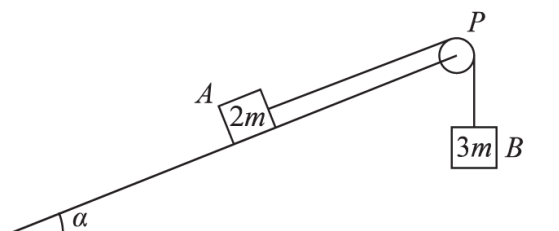


Figure 1

Two blocks,  $A$  and  $B$ , of masses  $2m$  and  $3m$  respectively, are attached to the ends of a light string.

Initially  $A$  is held at rest on a fixed rough plane.

The plane is inclined at angle  $\alpha$  to the horizontal ground, where  $\tan \alpha = \frac{5}{12}$

The string passes over a small smooth pulley,  $P$ , fixed at the top of the plane.

The part of the string from  $A$  to  $P$  is parallel to a line of greatest slope of the plane.  
Block  $B$  hangs freely below  $P$ , as shown in Figure 1.

The coefficient of friction between  $A$  and the plane is  $\frac{2}{3}$

The blocks are released from rest with the string taut and  $A$  moves up the plane.

The tension in the string immediately after the blocks are released is  $T$ .

The blocks are modelled as particles and the string is modelled as being inextensible.

(a) Show that  $T = \frac{12mg}{5}$  (8)

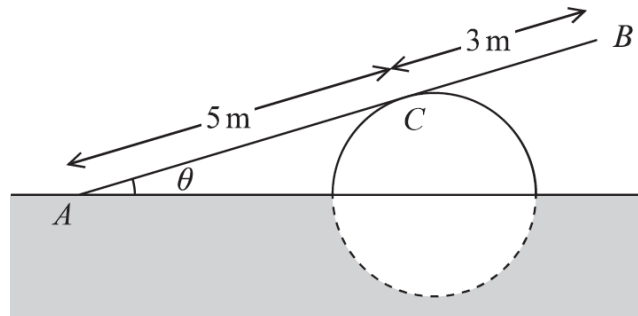
After  $B$  reaches the ground,  $A$  continues to move up the plane until it comes to rest before reaching  $P$ .

(b) Determine whether  $A$  will remain at rest, carefully justifying your answer. (2)

(c) Suggest two refinements to the model that would make it more realistic. (2)

(Total for Question 3 is 12 marks)

4.



**Figure 2**

A ramp,  $AB$ , of length 8 m and mass 20 kg, rests in equilibrium with the end  $A$  on rough horizontal ground.

The ramp rests on a smooth solid cylindrical drum which is partly under the ground. The drum is fixed with its axis at the same horizontal level as  $A$ .

The point of contact between the ramp and the drum is  $C$ , where  $AC = 5$  m, as shown in Figure 2.

The ramp is resting in a vertical plane which is perpendicular to the axis of the drum, at an angle  $\theta$  to the horizontal, where  $\tan \theta = \frac{7}{24}$

The ramp is modelled as a uniform rod.

(a) Explain why the reaction from the drum on the ramp at point  $C$  acts in a direction which is perpendicular to the ramp. (1)

(b) Find the magnitude of the resultant force acting on the ramp at  $A$ . (9)

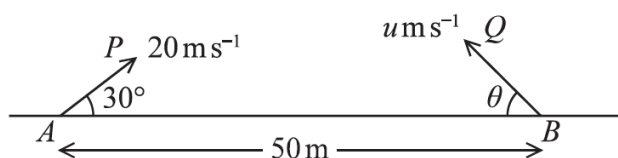
The ramp is still in equilibrium in the position shown in Figure 2 but the ramp is not now modelled as being uniform.

Given that the centre of mass of the ramp is assumed to be closer to  $A$  than to  $B$ ,

(c) state how this would affect the magnitude of the normal reaction between the ramp and the drum at  $C$ . (1)

**(Total for Question 4 is 11 marks)**

5.



**Figure 3**

The points  $A$  and  $B$  lie 50 m apart on horizontal ground.

At time  $t = 0$  two small balls,  $P$  and  $Q$ , are projected in the vertical plane containing  $AB$ .

Ball  $P$  is projected from  $A$  with speed  $20 \text{ m s}^{-1}$  at  $30^\circ$  to  $AB$ .

Ball  $Q$  is projected from  $B$  with speed  $u \text{ m s}^{-1}$  at angle  $\theta$  to  $BA$ , as shown in Figure 3.

At time  $t = 2$  seconds,  $P$  and  $Q$  collide.

Until they collide, the balls are modelled as particles moving freely under gravity.

- (a) Find the velocity of  $P$  at the instant before it collides with  $Q$ . (6)
- (b) Find
- (i) the size of angle  $\theta$ ,
  - (ii) the value of  $u$ . (6)
- (c) State one limitation of the model, other than air resistance, that could affect the accuracy of your answers. (1)

(Total for Question 5 is 13 marks)

**TOTAL FOR MECHANICS IS 50 MARKS**