

CANDIDATE  
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**MATHEMATICS**

**9709/52**

Paper 5 Mechanics 2 **(M2)**

**May/June 2018**

**1 hour 15 minutes**

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

**DO NOT WRITE IN ANY BARCODES.**

Answer **all** the questions in the space provided. If additional space is required, you should use the lined page at the end of this booklet. The question number(s) must be clearly shown.

Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.

Where a numerical value for the acceleration due to gravity is needed, use  $10 \text{ m s}^{-2}$ .

The use of an electronic calculator is expected, where appropriate.

You are reminded of the need for clear presentation in your answers.

At the end of the examination, fasten all your work securely together.

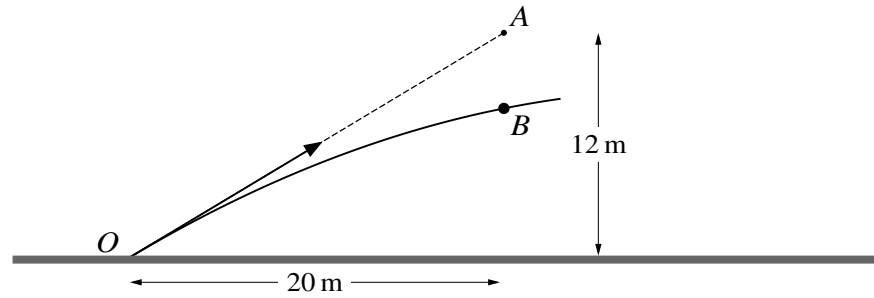
The number of marks is given in brackets [ ] at the end of each question or part question.

The total number of marks for this paper is 50.

This document consists of **14** printed pages and **2** blank pages.



1



A small ball  $B$  is projected from a point  $O$  on horizontal ground towards a point  $A$  12 m above the ground. 0.9 s after projection  $B$  has travelled a horizontal distance of 20 m and is vertically below  $A$  (see diagram).

(i) Find the angle and the speed of projection of  $B$ .

[4]

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(ii) Calculate the distance  $AB$  when  $B$  is vertically below  $A$ .

[2]

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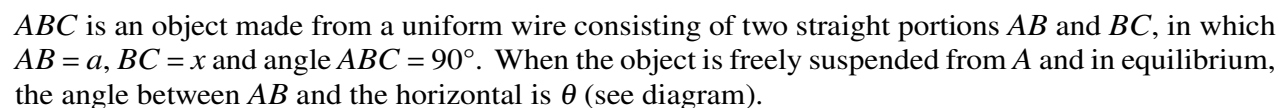
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- 2 One end of a light elastic string is attached to a fixed point  $O$ . The other end of the string is attached to a particle  $P$  of mass  $0.4\text{ kg}$ . The string has natural length  $0.6\text{ m}$  and modulus of elasticity  $24\text{ N}$ . The particle is released from rest at  $O$ . Find the two possible values of the distance  $OP$  for which the particle has speed  $1.5\text{ m s}^{-1}$ . [6]

This image shows a full page of white paper with horizontal dashed lines, typical of primary school writing paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.



- [illegible]

[illegible]

- 4 A particle  $P$  is projected from a point  $O$  on horizontal ground with initial speed  $20 \text{ m s}^{-1}$  and angle of projection  $30^\circ$ . At the instant  $t \text{ s}$  after projection, the horizontal and vertically upwards displacements of  $P$  from  $O$  are  $x \text{ m}$  and  $y \text{ m}$  respectively.

(i) Express  $x$  and  $y$  in terms of  $t$  and hence find the equation of the trajectory of  $P$ . [4]

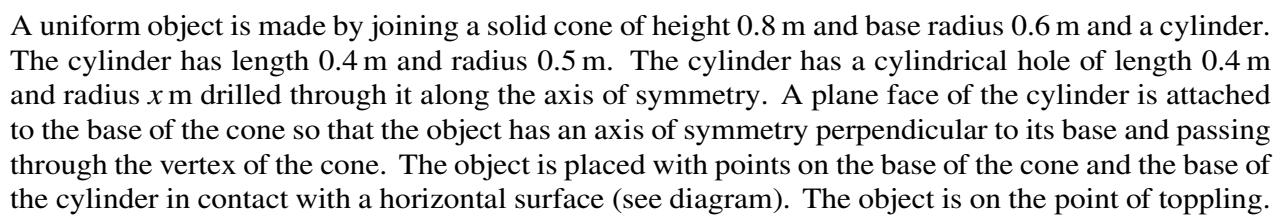
[illegible]

$P$  is at the same height above the ground at two points which are a horizontal distance apart of 15 m.

(ii) Calculate this height.

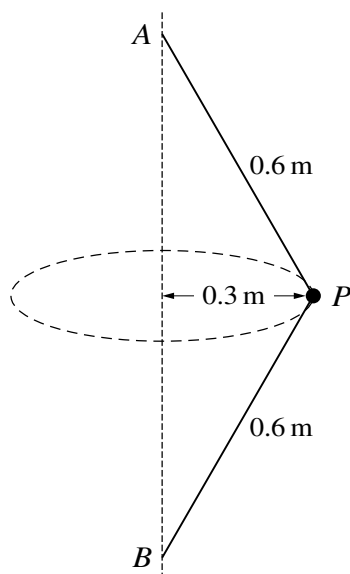
[3]

This image shows a full page of a document template. It consists of approximately 20 evenly spaced horizontal dotted lines across the entire width of the page, providing a guide for handwriting or typing. There are no margins, text, or other markings present.



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- This image shows a full page of white paper with horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.





A particle  $P$  of mass  $0.2\text{ kg}$  is attached to one end of a light inextensible string of length  $0.6\text{ m}$ . The other end of the string is attached to a fixed point  $A$ . The particle  $P$  is also attached to one end of a second light inextensible string of length  $0.6\text{ m}$ , the other end of which is attached to a fixed point  $B$  vertically below  $A$ . The particle moves in a horizontal circle of radius  $0.3\text{ m}$ , which has its centre at the mid-point of  $AB$ , with both strings straight (see diagram).

- (i) Calculate the least possible angular speed of  $P$ . [4]

This image shows a full page of white paper with horizontal dashed lines, typical of primary school handwriting practice paper. The lines are evenly spaced and run across the entire width of the page. There are no margins, text, or other markings present.

(ii) Find the greatest possible speed of  $P$ . [5]

This image shows a full page of white paper with horizontal dotted lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the page.

- 7 A particle  $P$  of mass  $0.2 \text{ kg}$  is released from rest at a point  $O$  above horizontal ground. At time  $t \text{ s}$  after its release the velocity of  $P$  is  $v \text{ m s}^{-1}$  downwards. A vertically downwards force of magnitude  $0.6t \text{ N}$  acts on  $P$ . A vertically upwards force of magnitude  $ke^{-t} \text{ N}$ , where  $k$  is a constant, also acts on  $P$ .

(i) Show that  $\frac{dv}{dt} = 10 - 5ke^{-t} + 3t$ . [2]

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- (ii) Find the greatest value of  $k$  for which  $P$  does not initially move upwards. [3]

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- (iii) Given that  $k = 1$ , and that  $P$  strikes the ground when  $t = 2$ , find the height of  $O$  above the ground. [5]

[illegible]

[illegible]



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