

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS
AS GCE**

4761/01

MATHEMATICS (MEI)

Mechanics 1

QUESTION PAPER

FRIDAY 17 JUNE 2016: Afternoon

**DURATION: 1 hour 30 minutes
plus your additional time allowance**

MODIFIED ENLARGED

**Candidates answer on the Printed Answer Book or any other
suitable paper provided by the centre. The Printed Answer Book
may be enlarged by the centre.**

OCR SUPPLIED MATERIALS:

Insert for question 1(i) and 7

OTHER MATERIALS REQUIRED:

Scientific or graphical calculator

READ INSTRUCTIONS OVERLEAF



INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book or on the paper provided by the centre. Please write clearly and in capital letters.

IF YOU USE THE PRINTED ANSWER BOOK WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).

Use black ink. HB pencil may be used for graphs and diagrams only.

Read each question carefully. Make sure you know what you have to do before starting your answer.

Answer ALL the questions.

You are permitted to use a scientific or graphical calculator in this paper.

Final answers should be given to a degree of accuracy appropriate to the context.

The acceleration due to gravity is denoted by $g \text{ m s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION FOR CANDIDATES

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

You are advised that an answer may receive NO MARKS unless you show sufficient detail of the working to indicate that a correct method is being used.

The total number of marks for this paper is 72.

Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

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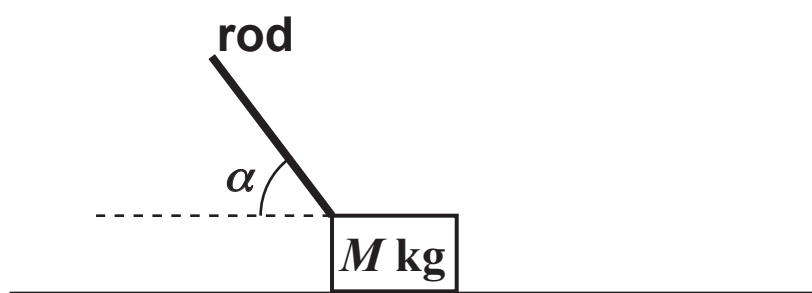
SECTION A (36 MARKS)

- 1 Fig. 1 below shows a block of mass M kg being pushed over level ground by means of a light rod. The force, T N, this exerts on the block is along the line of the rod.

The ground is rough.

The rod makes an angle α with the horizontal.

Fig. 1

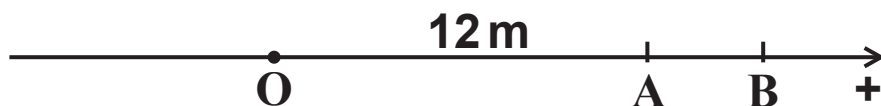


- (i) Draw a diagram showing all the forces acting on the block. You may use the insert. [3]
- (ii) You are given that $M = 5$, $\alpha = 60^\circ$, $T = 40$ and the acceleration of the block is 1.5 m s^{-2} .

Find the frictional force. [3]

- 2 A particle moves on the straight line shown in Fig. 2 below. The positive direction is indicated on the diagram.

Fig. 2



The time, t , is measured in seconds. The particle has constant acceleration, $a \text{ m s}^{-2}$.

Initially it is at the point O and has velocity $u \text{ m s}^{-1}$.

When $t = 2$, the particle is at A where OA is 12 m.
The particle is also at A when $t = 6$.

(i) Write down two equations in u and a and solve them. [4]

(ii) The particle changes direction when it is at B.

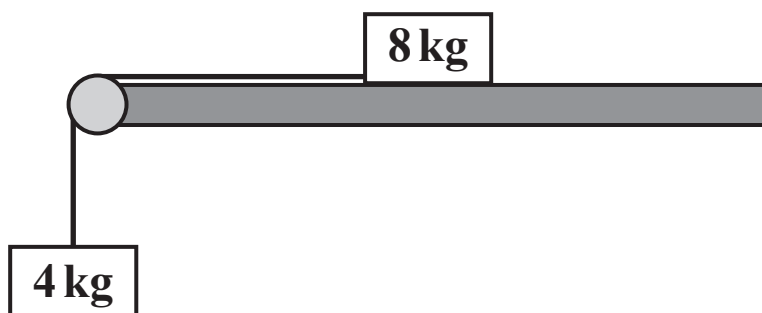
Find the distance AB. [3]

- 3 Fig. 3.1 below shows a block of mass 8 kg on a smooth horizontal table.

This block is connected by a light string passing over a smooth pulley to a block of mass 4 kg which hangs freely. The part of the string between the 8 kg block and the pulley is parallel to the table.

The system has acceleration $a \text{ m s}^{-2}$.

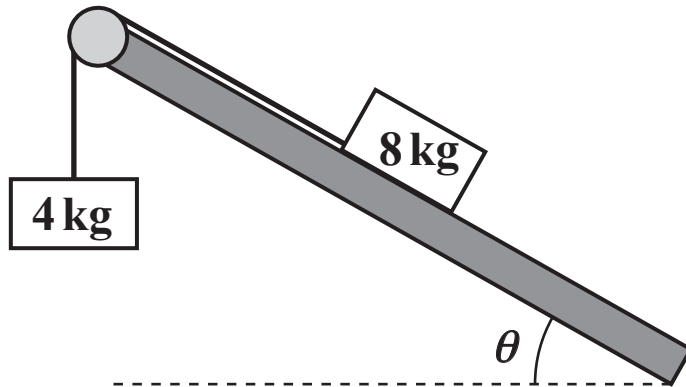
Fig. 3.1



- (i) Write down two equations of motion, one for each block. [2]
- (ii) Find the value of a . [2]

The table is now tilted at an angle of θ to the horizontal as shown in Fig. 3.2 below. The system is set up as before; the 4 kg block still hangs freely.

Fig. 3.2



(iii) The system is now in equilibrium.
Find the value of θ . [4]

- 4 A particle is initially at the origin, moving with velocity \mathbf{u} . Its acceleration \mathbf{a} is constant.

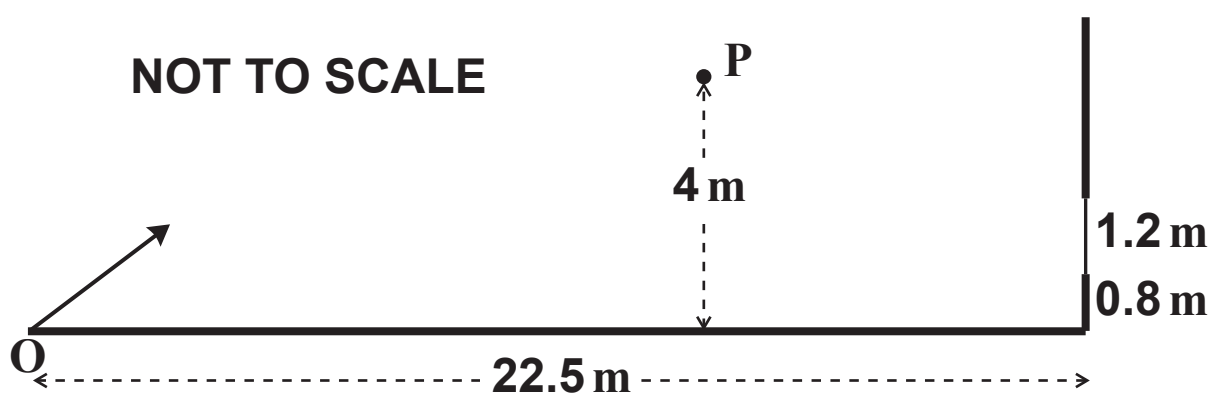
At time t its displacement from the origin is $\mathbf{r} = \begin{pmatrix} x \\ y \end{pmatrix}$,
where $\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 2 \\ 6 \end{pmatrix}t - \begin{pmatrix} 0 \\ 4 \end{pmatrix}t^2$.

- (i) Write down \mathbf{u} and \mathbf{a} as column vectors. [2]
- (ii) Find the speed of the particle when $t = 2$. [3]
- (iii) Show that the equation of the path of the particle is $y = 3x - x^2$. [3]

- 5 Mr McGregor is a keen vegetable gardener. A pigeon that eats his vegetables is his great enemy.

One day he sees the pigeon sitting on a small branch of a tree. He takes a stone from the ground and throws it. The trajectory of the stone is in a vertical plane that contains the pigeon. The same vertical plane intersects the window of his house. The situation is illustrated in Fig. 5 below.

Fig. 5



The stone is thrown from point O on level ground. Its initial velocity is 15 m s^{-1} in the horizontal direction and 8 m s^{-1} in the vertical direction.

The pigeon is at point P which is 4 m above the ground.

The house is 22.5 m from O.

The bottom of the window is 0.8 m above the ground and the window is 1.2 m high.

Show that the stone does not reach the height of the pigeon.

Determine whether the stone hits the window. [7]

SECTION B (36 MARKS)

6 In this question you should take g to be 10 m s^{-2} .

Piran finds a disused mineshaft on his land and wants to know its depth, d metres.

Local records state that the mineshaft is between 150 and 200 metres deep.

He drops a small stone down the mineshaft and records the time, T seconds, until he hears it hit the bottom. It takes 8.0 seconds.

Piran tries three models, A, B and C.

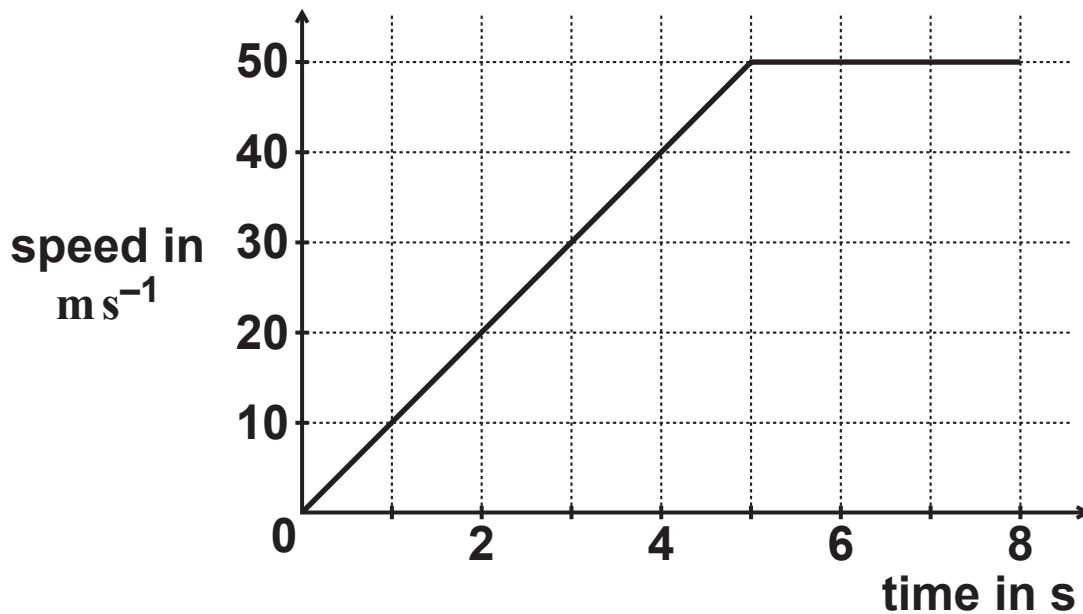
In model A, Piran uses the formula $d = 5T^2$ to estimate the depth.

- (i) Find the depth that model A gives and comment on whether it is consistent with the local records.

Explain how the formula in model A is obtained. [4]

In model B, Piran uses the speed-time graph in Fig. 6 below.

Fig. 6



- (ii) Calculate the depth of the mineshaft according to model B.

Comment on whether this depth is consistent with the local records. [4]

- (iii) Describe briefly one respect in which model B is the same as model A and one respect in which it is different. [2]

Piran then tries model C in which the speed, $v \text{ m s}^{-1}$, is given by

$$v = 10t - t^2 \text{ for } 0 \leq t \leq 5,$$

$$v = 25 \text{ for } 5 < t \leq 8.$$

(iv) Calculate the depth of the mineshaft according to model C.

Comment on whether this depth is consistent with the local records. [6]

(v) Describe briefly one respect in which model C is similar to model B and one respect in which it is different. [2]

- 7 Fig. 7 in the insert illustrates a situation on a building site. An unexploded bomb is being lifted by light ropes that pass over smooth pulleys. The ropes are attached to winches V and W.**

The weight of the bomb is 7500 N.

The winches are on horizontal ground and are at the same level.

The sloping parts of the ropes from V and W are at angles α and β to the horizontal.

The point P is level with the horizontal sections of the ropes and is 16 m and 9 m from the two pulleys, as shown.

The winches are controlled so that the bomb moves in a vertical line through P. The tension in the rope attached to winch W is kept constant at 8000 N. The tension, T N, in the rope attached to winch V is varied.

The distance between the top of the bomb, B, and the point P is d metres.

At a particular stage in the lift, $d = 12$ and $T = 6000$.

(i) Find the values of $\cos\alpha$ and $\cos\beta$ at this stage. [1]

(ii) Verify that, at this stage, the horizontal component of the bomb's acceleration is zero. Find the vertical component of its acceleration. [7]

At a later stage, the bomb is higher up and so the values of d , T , α and β have all changed.

(iii) Show that $T = \frac{8000 \cos \beta}{\cos \alpha}$.

Hence show that $T = \frac{4500 \sqrt{d^2 + 256}}{\sqrt{d^2 + 81}}$. [4]

(iv) Find the acceleration of the bomb when $d = 6.75$. [4]

(v) Explain briefly why it is not possible for the bomb to be in equilibrium with B at P.

What could you say about the acceleration of the bomb if B were at P and the tensions in the two ropes were equal? [2]

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