OXFORD CAMBRIDGE AND RSA EXAMINATIONS

AS GCE

4761/01

MATHEMATICS (MEI)

Mechanics 1

QUESTION PAPER

MONDAY 28 JANUARY 2013: Morning

DURATION: 1 hour 30 minutes
plus your additional time allowance

MODIFIED ENLARGED 18pt

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

OCR SUPPLIED MATERIALS:

Printed Answer Book 4761/01
MEI Examination Formulae and Tables (MF2)
Loose sheet for question 6 (inserted)

OTHER MATERIALS REQUIRED:

Scientific or graphical calculator

READ INSTRUCTIONS OVERLEAF

DC (NH/CGW) 1466985457 71831

INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.

- **The Question Paper will be found in the centre of the Printed Answer Book.**
- **Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.**
- **WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED IN THE PRINTED ANSWER BOOK. 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 $g\,\mathrm{m\,s^{-2}}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.**

INFORMATION FOR CANDIDATES

This information is the same on the Printed Answer Book and the Question Paper.

- **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.**

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

- **Do not send this Question Paper for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.**

SECTION A (36 marks)

1 **Fig. 1 below shows a block of mass 3 kg on a plane which is inclined at an angle of 30° to the horizontal.**

A force *P* N is applied to the block parallel to the plane in the upwards direction.

The plane is rough so that a frictional force of 10 N opposes the motion.

The block is moving at constant speed up the plane.

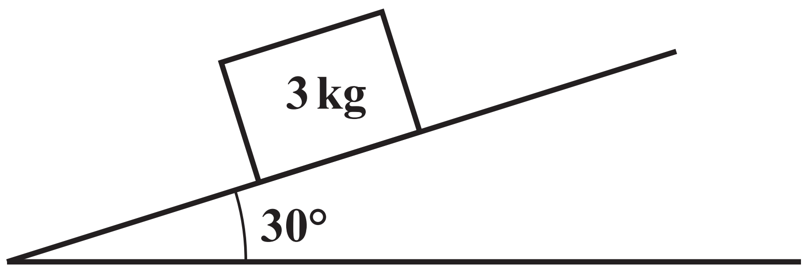

FIG. 1

(i) **Mark and label all the forces acting on the block. [3]**

(ii) **Calculate the magnitude of the normal reaction of the plane on the block. [1]**

(iii) **Calculate the magnitude of the force *P*. [2]**

2 **In this question, the unit vectors $\begin{pmatrix}1\\0\end{pmatrix}$ and $\begin{pmatrix}0\\1\end{pmatrix}$ are in the directions east and north.**

Distance is measured in metres and time, *t*, in seconds.

A radio-controlled toy car moves on a flat horizontal surface. A child is standing at the origin and controlling the car.

When $t = 0$, the displacement of the car from the origin is $\begin{pmatrix}0\\-2\end{pmatrix}$ m, and the car has velocity $\begin{pmatrix}2\\0\end{pmatrix}$ $\mathrm{m\,s^{-1}}$.

The acceleration of the car is constant and is $\begin{pmatrix}-1\\1\end{pmatrix}$ $\mathrm{m\,s^{-2}}$.

(i) Find the velocity of the car at time *t* and its speed when $t = 8$. [4]

(ii) Find the distance of the car from the child when $t = 8$. [4]

3 **Fig. 3 below shows two people, Sam and Tom, pushing a car of mass 1000 kg along a straight line *l* on level ground.**

Sam pushes with a constant horizontal force of 300 N at an angle of 30° to the line *l*.

Tom pushes with a constant horizontal force of 175 N at an angle of 15° to the line *l*.

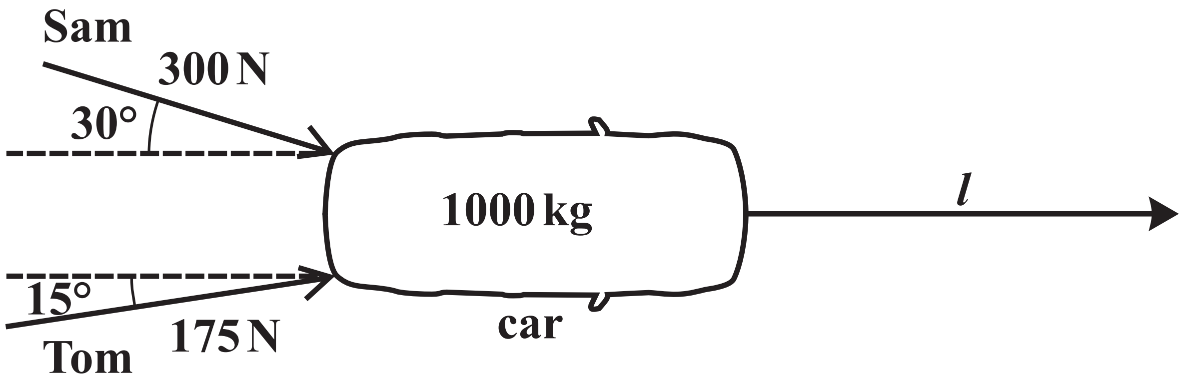

FIG. 3

(i) **The car starts at rest and moves with constant acceleration. After 6 seconds it has travelled 7.2 m.**

Find its acceleration. [3]

(ii) **Find the resistance force acting on the car along the line *l*. [4]**

(iii) **The resultant of the forces exerted by Sam and Tom is not in the direction of the car's acceleration. Explain briefly why. [1]**

4 **A particle is travelling along a straight line with constant acceleration. P, O and Q are points on the line, as illustrated in Fig. 4. The distance from P to O is 5 m and the distance from O to Q is 30 m.**

FIG. 4

Initially the particle is at O. After 10 s, it is at Q and its velocity is $9\,\mathrm{m\,s^{-1}}$ in the direction $\overrightarrow{OQ}$.

(i) Find the initial velocity and the acceleration of the particle. [4]

(ii) Prove that the particle is never at P. [3]

5 Ali is throwing flat stones onto water, hoping that they will bounce, as illustrated in Fig. 5 below.

Ali throws one stone from a height of 1.225 m above the water with initial speed $20\,\mathrm{m\,s^{-1}}$ in a horizontal direction. Air resistance should be neglected.

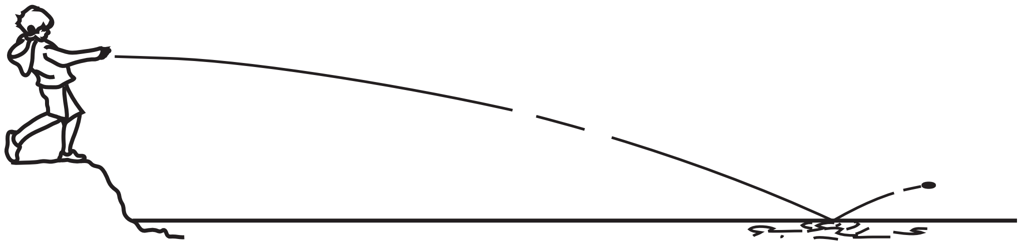

FIG. 5

(i) Find the time it takes for the stone to reach the water. [2]

(ii) Find the speed of the stone when it reaches the water and the angle its trajectory makes with the horizontal at this time. [5]

SECTION B (36 marks)

6 The speed of a 100 metre runner in $\mathrm{m\,s^{-1}}$ is measured electronically every 4 seconds.

The measurements are plotted as points on the speed-time graph in Fig. 6. (Fig. 6 is provided on a separate sheet.) The vertical dotted line is drawn through the runner's finishing time.

Fig. 6 also illustrates Model P in which the points are joined by straight lines.

(i) Use Model P to estimate

(*A*) the distance the runner has gone at the end of 12 seconds,

(*B*) how long the runner took to complete 100 m. [6]

A mathematician proposes Model Q in which the runner's speed, $v\ \mathrm{m\,s^{-1}}$ at time t s, is given by

$$v = \frac{5}{2}t - \frac{1}{8}t^2.$$

(ii) Verify that Model Q gives the correct speed for $t = 8$. [1]

(iii) Use Model Q to estimate the distance the runner has gone at the end of 12 seconds. [4]

(iv) The runner was timed at 11.35 seconds for the 100 m.

Which model places the runner closer to the finishing line at this time? [3]

(v) Find the greatest acceleration of the runner according to each model. [4]

7 **A block of weight 50 N is in equilibrium, suspended from fixed points A and B which are 2 m apart on a horizontal ceiling.**

Fig. 7.1 below illustrates one way of doing this. A light, inextensible string of length 2.8 m is passed round a small smooth light pulley attached to a point C on the block. The parts of the string from C to A and from C to B should be treated as straight lines making angles θ and ϕ with the vertical.

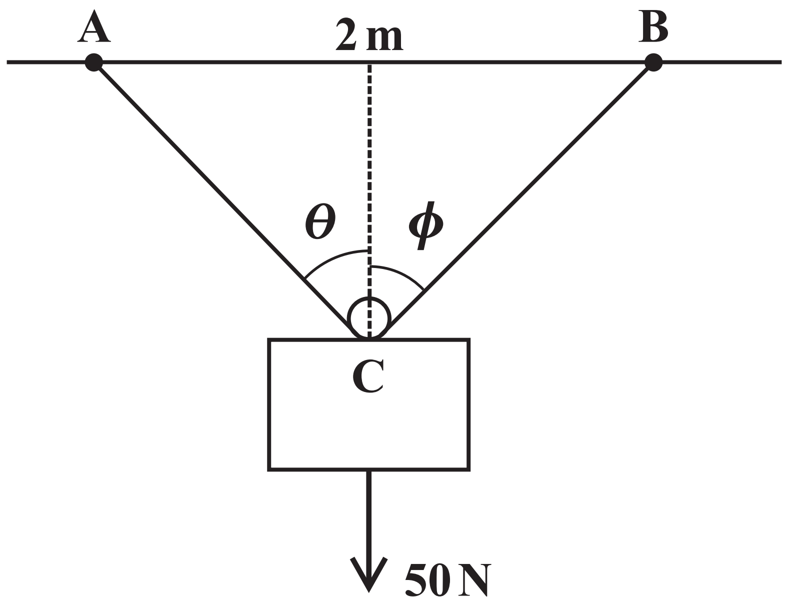

FIG. 7.1

(i) (*A*) State which piece of the information that you have been given tells you that the tension in the string is the same on each side of the pulley. [1]

(*B*) Hence show that $\theta = \phi$. [2]

(ii) Show that $\cos\theta = \frac{\sqrt{24}}{7}$. [2]

(iii) Find the tension in the string. [3]

Fig. 7.2 below illustrates another way of suspending the block from the same two points, A and B, with the string now cut into two parts, AC and BC. The length of AC is 1.2 m and BC is 1.6 m. The angles the strings make with the horizontal are α and β. The tension in the string AC is T_1 N and the tension in the string BC is T_2 N.

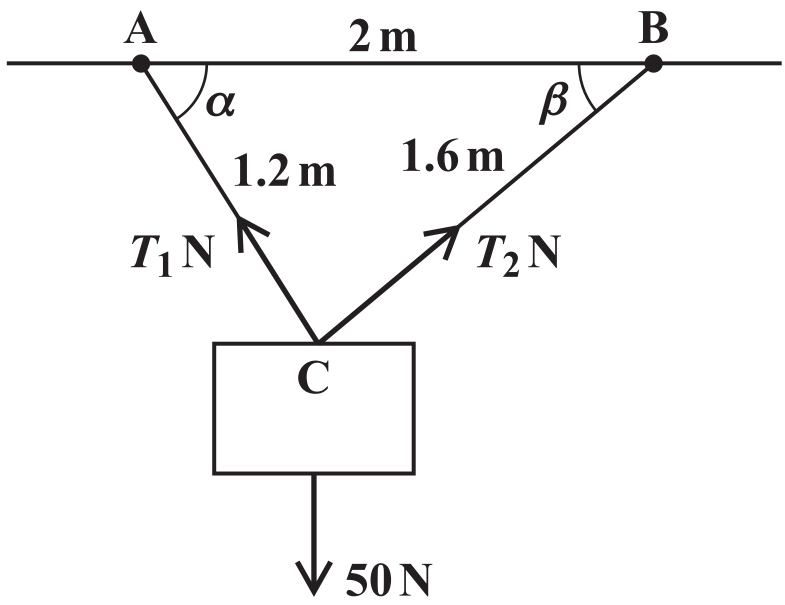

FIG. 7.2

(iv) Show that $\angle ACB = 90°$.

Write down the values of $\cos\alpha$ and $\cos\beta$. [2]

(v) Find T_1 and T_2. [5]

In a different arrangement, the string is cut so that the lengths of the two parts are 0.5 m and 2.3 m.

(vi) Describe how the block hangs in equilibrium in this case and state the tensions in the two strings. [3]

THERE ARE NO QUESTIONS PRINTED ON THIS PAGE.