OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

MATHEMATICS (MEI)

4761

Mechanics 1

QUESTION PAPER

Candidates answer on the printed answer book.

OCR supplied materials:
- Printed answer book 4761
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Thursday 16 June 2011
Afternoon

Duration: 1 hour 30 minutes

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. 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.
- Do **not** write in the bar codes.
- 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 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**.
- The printed answer book consists of **16** pages. The question paper consists of **8** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

- Do not send this question paper for marking; it should be retained in the centre or destroyed.

Section A (36 marks)

1 A pellet is fired vertically upwards at a speed of $11\,\text{m s}^{-1}$. Assuming that air resistance may be neglected, calculate the speed at which the pellet hits a ceiling 2.4 m above its point of projection. **[3]**

2 A particle travels with constant acceleration along a straight line. A and B are points on this line 8 m apart.

The motion of the particle is as follows.

- Initially it is at A.
- After 32 s it is at B.
- When it is at B its speed is $2.25\,\text{m s}^{-1}$ and it is moving away from A.

In either order, calculate the acceleration and the initial velocity of the particle, making the directions clear. **[5]**

3 Force **F** is $\begin{pmatrix} -2 \\ 3 \\ -4 \end{pmatrix}$ N, force **G** is $\begin{pmatrix} -6 \\ y \\ z \end{pmatrix}$ N and force **H** is $\begin{pmatrix} 3 \\ -5 \\ -1 \end{pmatrix}$ N.

(i) Given that **F** and **G** act in parallel lines, find y and z. **[2]**

Forces **F** and **H** are the only forces acting on an object of mass 5 kg.

(ii) Calculate the acceleration of the object. Calculate also the magnitude of this acceleration. **[5]**

4 Fig. 4 shows a block of mass 15 kg on a smooth plane inclined at 20° to the horizontal. The block is held in equilibrium by a horizontal force of magnitude P N.

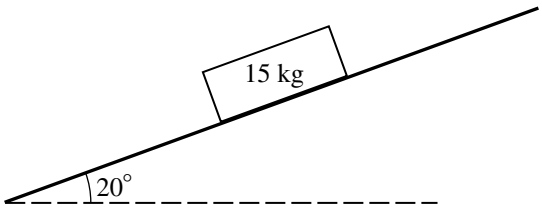

Fig. 4

(i) Show all the forces acting on the block. **[2]**

(ii) Calculate P. **[3]**

5 A small object is projected over horizontal ground from a point O at ground level and makes a loud noise on landing. It has an initial speed of $30\,\text{m s}^{-1}$ at 35° to the horizontal.

Assuming that air resistance on the object may be neglected and that the speed of sound in air is $343\,\text{m s}^{-1}$, calculate how long after projection the noise is heard at O. **[8]**

6 In this question, **i** and **j** are unit vectors east and north respectively. Position vectors are with respect to an origin O. Time t is in seconds.

A skater has a constant acceleration of $-2\mathbf{j}\,\text{m}\,\text{s}^{-2}$. At $t = 0$, his velocity is $4\mathbf{i}\,\text{m}\,\text{s}^{-1}$ and his position vector is $3\mathbf{j}\,\text{m}$.

(i) Find expressions in terms of t for the velocity and the position vector of the skater at time t. **[5]**

(ii) Calculate as a bearing the direction of motion of the skater when $t = 2.5$. **[3]**

Section B (36 marks)

7 A ring is moving on a straight wire. Its velocity is v m s^{-1} at time t seconds after passing a point Q.

Model A for the motion of the ring gives the velocity-time graph for $0 \leqslant t \leqslant 6$ shown in Fig. 7.

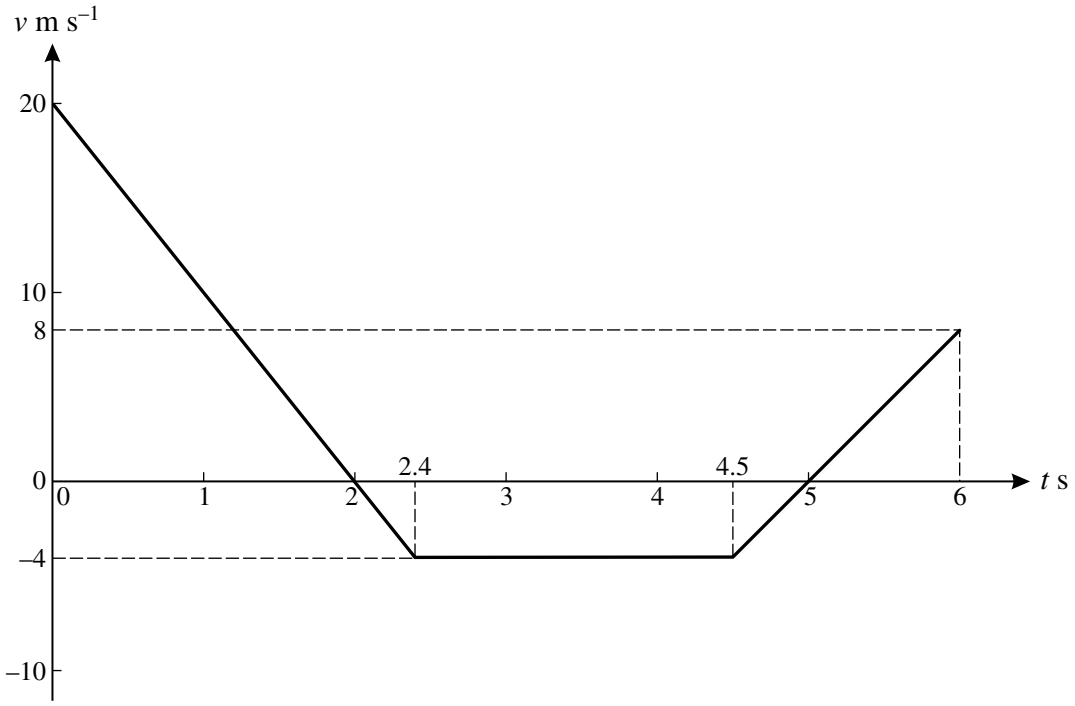

Fig. 7

Use model A to calculate the following.

(i) The acceleration of the ring when $t = 0.5$. **[2]**

(ii) The displacement of the ring from Q when

(*A*) $t = 2$,

(*B*) $t = 6$. **[5]**

In an alternative model B, the velocity of the ring is given by $v = 2t^2 - 14t + 20$ for $0 \leqslant t \leqslant 6$.

(iii) Calculate the acceleration of the ring at $t = 0.5$ as given by model B. **[3]**

(iv) Calculate by how much the models differ in their values for the least v in the time interval $0 \leqslant t \leqslant 6$. **[4]**

(v) Calculate the displacement of the ring from Q when $t = 6$ as given by model B. **[4]**

8 A trolley C of mass 8 kg with rusty axle bearings is initially at rest on a horizontal floor.

The trolley stays at rest when it is pulled by a horizontal string with tension 25 N, as shown in Fig. 8.1.

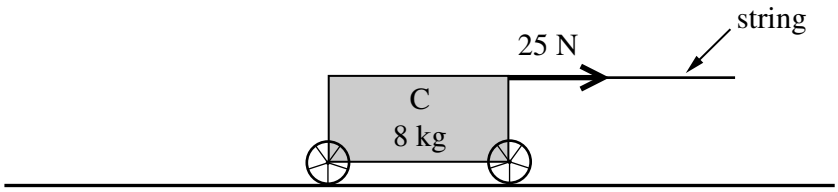

Fig. 8.1

(i) State the magnitude of the horizontal resistance opposing the pull. **[1]**

A second trolley D of mass 10 kg is connected to trolley C by means of a light, horizontal rod.

The string now has tension 50 N, and is at an angle of 25° to the horizontal, as shown in Fig. 8.2. The two trolleys stay at rest.

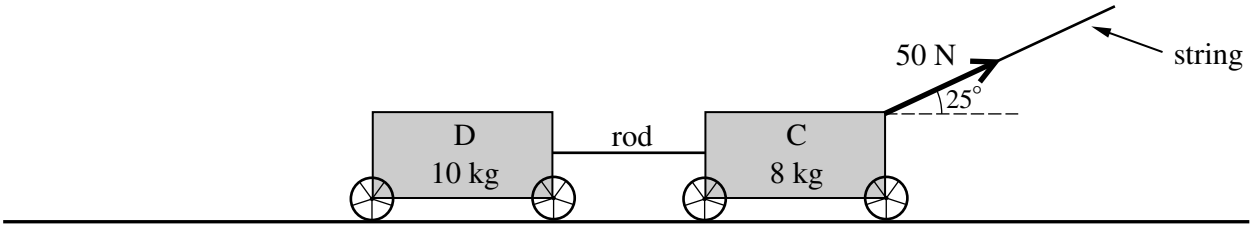

Fig. 8.2

(ii) Calculate the magnitude of the total horizontal resistance acting on the two trolleys opposing the pull. **[2]**

(iii) Calculate the normal reaction of the floor on trolley C. **[3]**

The axle bearings of the trolleys are oiled and the total horizontal resistance to the motion of the two trolleys is now 20 N. The two trolleys are still pulled by the string with tension 50 N, as shown in Fig. 8.2.

(iv) Calculate the acceleration of the trolleys. **[3]**

In a new situation, the trolleys are on a slope at 5° to the horizontal and are initially travelling down the slope at 3 m s^{-1}. The resistances are 15 N to the motion of D and 5 N to the motion of C. There is no string attached. The rod connecting the trolleys is parallel to the slope. This situation is shown in Fig. 8.3.

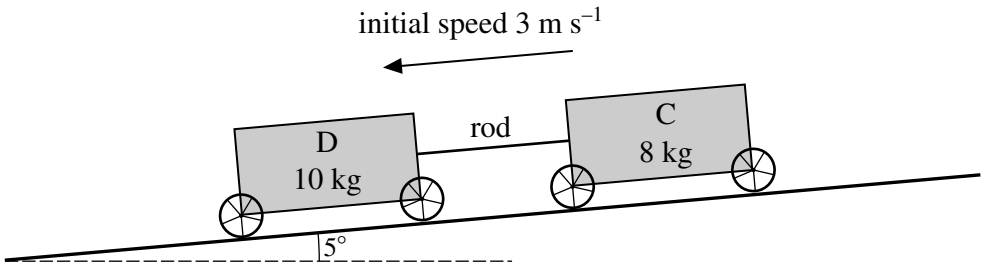

Fig. 8.3

(v) Calculate the speed of the trolleys after 2 seconds and also the force in the rod connecting the trolleys, stating whether this rod is in tension or thrust (compression). **[9]**

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