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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

Wednesday 26 January 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 $g\ \mathrm{m\,s^{-2}}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION FOR CANDIDATES

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- 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 **12** 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.

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Section A (36 marks)

1 An object C is moving along a vertical straight line. Fig. 1 shows the velocity-time graph for part of its motion. Initially C is moving upwards at $14\,\mathrm{m\,s^{-1}}$ and after 10 s it is moving downwards at $6\,\mathrm{m\,s^{-1}}$.

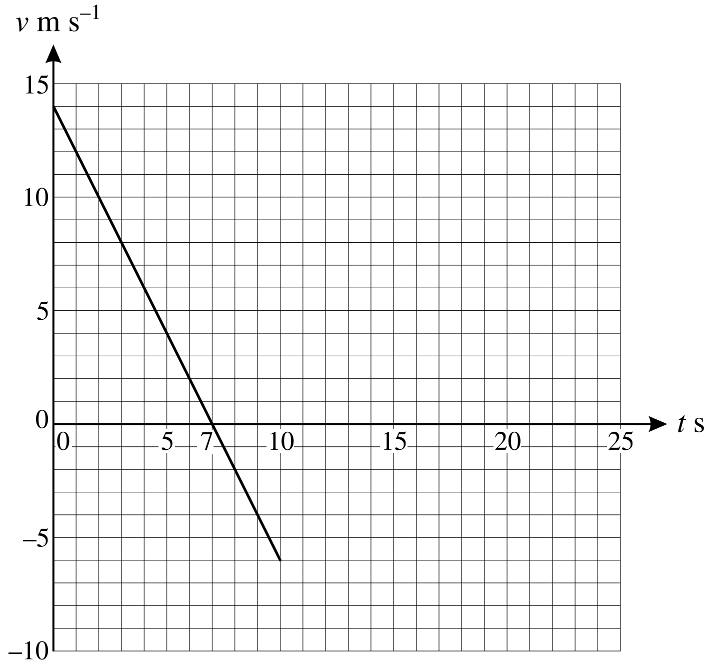

Fig. 1

C then moves as follows.

- In the interval $10 \leqslant t \leqslant 15$, the velocity of C is constant at $6\,\mathrm{m\,s^{-1}}$ downwards.
- In the interval $15 \leqslant t \leqslant 20$, the velocity of C increases uniformly so that C has zero velocity at $t = 20$.

(i) Complete the velocity-time graph for the motion of C in the time interval $0 \leqslant t \leqslant 20$. **[2]**

(ii) Calculate the acceleration of C in the time interval $0 < t < 10$. **[2]**

(iii) Calculate the displacement of C from $t = 0$ to $t = 20$. **[4]**

2 Fig. 2 shows two forces acting at A. The figure also shows the perpendicular unit vectors **i** and **j** which are respectively horizontal and vertically upwards.

The resultant of the two forces is **F** N.

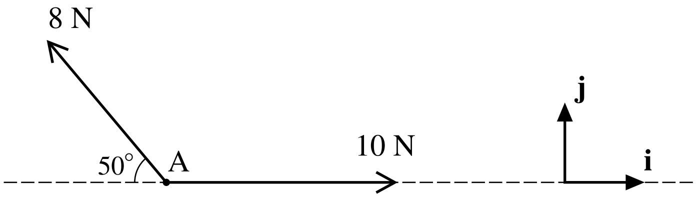

Fig. 2

(i) Find **F** in terms of **i** and **j**, giving your answer correct to three significant figures. **[3]**

(ii) Calculate the magnitude of **F** and the angle that **F** makes with the upward vertical. **[3]**

3 Two cars, P and Q, are being crashed as part of a film 'stunt'.

At the start

- P is travelling directly towards Q with a speed of $8\,\text{m}\,\text{s}^{-1}$,
- Q is instantaneously at rest and has an acceleration of $4\,\text{m}\,\text{s}^{-2}$ directly towards P.

P continues with the same velocity and Q continues with the same acceleration. The cars collide T seconds after the start.

(i) Find expressions in terms of T for how far each of the cars has travelled since the start. **[2]**

At the start, P is 90 m from Q.

(ii) Show that $T^2 + 4T - 45 = 0$ and hence find T. **[5]**

4 At time t seconds, a particle has position with respect to an origin O given by the vector

$$\mathbf{r} = \begin{pmatrix} 8t \\ 10t^2 - 2t^3 \end{pmatrix},$$

where $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 1 \end{pmatrix}$ are perpendicular unit vectors east and north respectively and distances are in metres.

(i) When $t = 1$, the particle is at P. Find the bearing of P from O. **[2]**

(ii) Find the velocity of the particle at time t and show that it is never zero. **[3]**

(iii) Determine the time(s), if any, when the acceleration of the particle is zero. **[3]**

5 Fig. 5 shows two boxes, A of mass 12 kg and B of mass 6 kg, sliding in a straight line on a rough horizontal plane. The boxes are connected by a light rigid rod which is parallel to the line of motion. The only forces acting on the boxes in the line of motion are those due to the rod and a constant force of F N on each box.

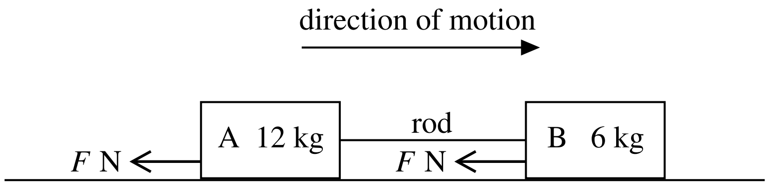

Fig. 5

The boxes have an initial speed of $1.5\,\text{m}\,\text{s}^{-1}$ and come to rest after sliding a distance of 0.375 m.

(i) Calculate the deceleration of the boxes and the value of F. **[4]**

(ii) Calculate the magnitude of the force in the rod and state, with a reason, whether it is a tension or a thrust (compression). **[3]**

Section B (36 marks)

6 A toy sledge of mass 4 kg is being pulled in a straight line by a light string. The resistance to its motion is 6 N.

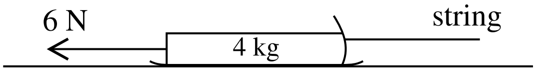

Fig. 6.1

At one time, the string is horizontal and the sledge is on horizontal ground, as shown in Fig. 6.1. The acceleration of the sledge is $3\,\text{m}\,\text{s}^{-2}$ forwards.

(i) Calculate the tension in the string. **[3]**

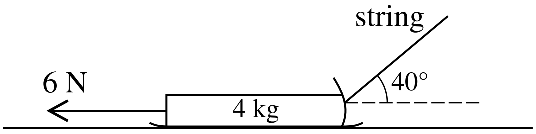

Fig. 6.2

At another time, the sledge is again on horizontal ground but the string is now at 40° to the horizontal, as shown in Fig. 6.2. The tension in the string is 25 N.

(ii) Calculate the acceleration of the sledge. **[3]**

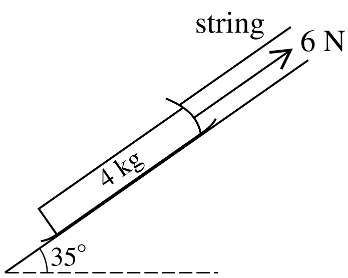

Fig. 6.3

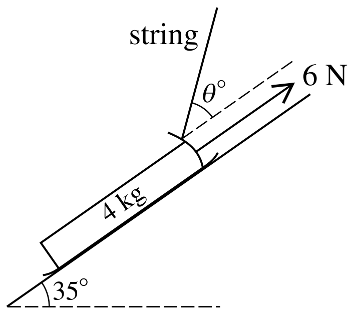

Fig. 6.4

In another situation the sledge is on a slope inclined at 35° to the horizontal, as shown in Fig. 6.3. It is held in equilibrium by the light string parallel to the slope. The resistance to motion of 6 N acts up the slope.

(iii) Calculate the tension in the string. **[3]**

The sledge is now held in equilibrium with the light string inclined at $\theta°$ to the slope, as shown in Fig. 6.4. The tension in the string is 25 N and the resistance to motion remains 6 N acting up the slope.

(iv) (*A*) Show all the forces acting on the sledge. **[2]**

(*B*) Calculate the angle θ. **[3]**

(*C*) Calculate the normal reaction of the slope on the sledge. **[3]**

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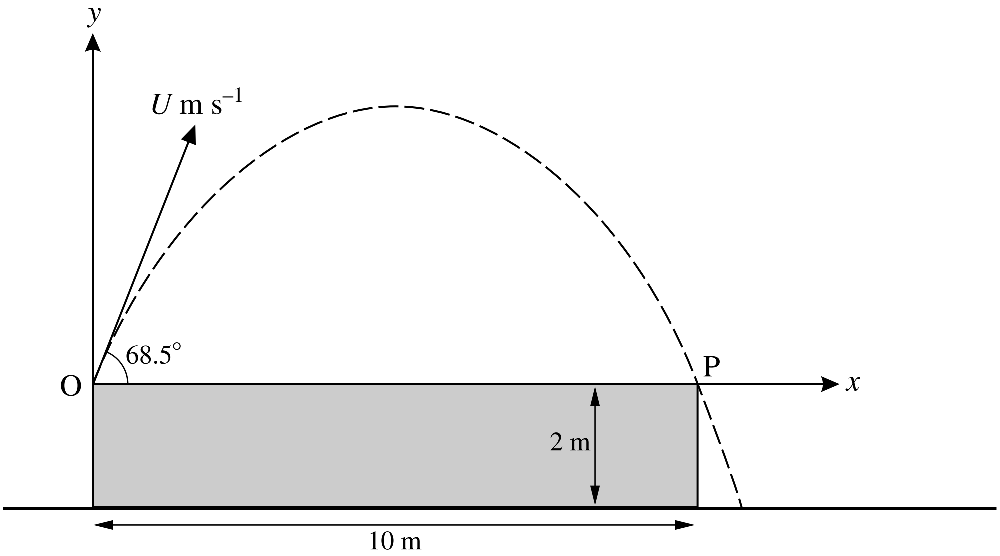

Fig. 7

Fig. 7 shows a platform 10 m long and 2 m high standing on horizontal ground. A small ball projected from the surface of the platform at one end, O, just misses the other end, P. The ball is projected at 68.5° to the horizontal with a speed of U m s^{-1}. Air resistance may be neglected.

At time t seconds after projection, the horizontal and vertical displacements of the ball from O are x m and y m.

(i) Obtain expressions, in terms of U and t, for

(A) x,

(B) y. **[3]**

(ii) The ball takes T s to travel from O to P.

Show that $T = \dfrac{U \sin 68.5^\circ}{4.9}$ and write down a second equation connecting U and T. **[4]**

(iii) Hence show that $U = 12.0$ (correct to three significant figures). **[3]**

(iv) Calculate the horizontal distance of the ball from the platform when the ball lands on the ground. **[5]**

(v) Use the expressions you found in part **(i)** to show that the cartesian equation of the trajectory of the ball in terms of U is

$$y = x \tan 68.5^\circ - \frac{4.9x^2}{U^2(\cos 68.5^\circ)^2}.$$

Use this equation to show again that $U = 12.0$ (correct to three significant figures). **[4]**

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Centre number						Candidate number				

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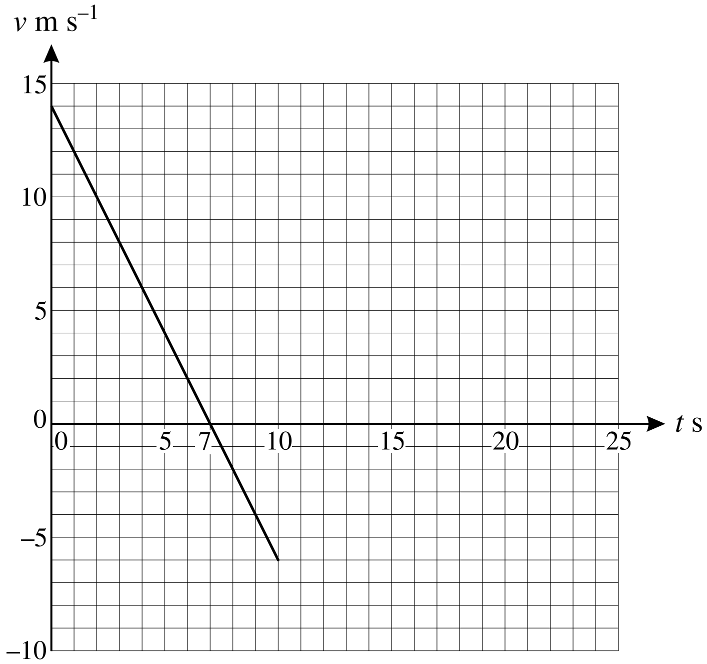
Section A (36 marks)

1 (i)



1 (ii)

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2 (i)	
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3 (i)	
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4 (i)	
4 (ii)	
4 (iii)	

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5 (i)	

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5 (ii)

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Section B (36 marks)

6 (i)

6 (ii)

6 (iii)

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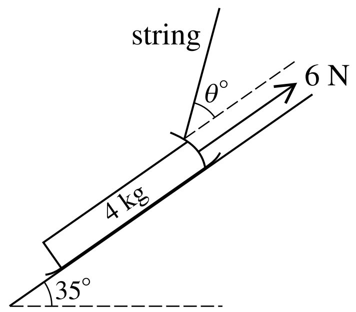
6(iv)(A)	
6(iv)(B)	
6(iv)(C)	

7 (i) (A)	
7 (i) (B)	
7 (ii)	
7 (iii)	

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7 (iv)	
7 (v)	

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