

**ADVANCED SUBSIDIARY GCE
MATHEMATICS (MEI)**

Mechanics 1

4761

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 $g \text{ m s}^{-2}$. 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 **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.

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 m s^{-1} and after 10 s it is moving downwards at 6 m s^{-1} .

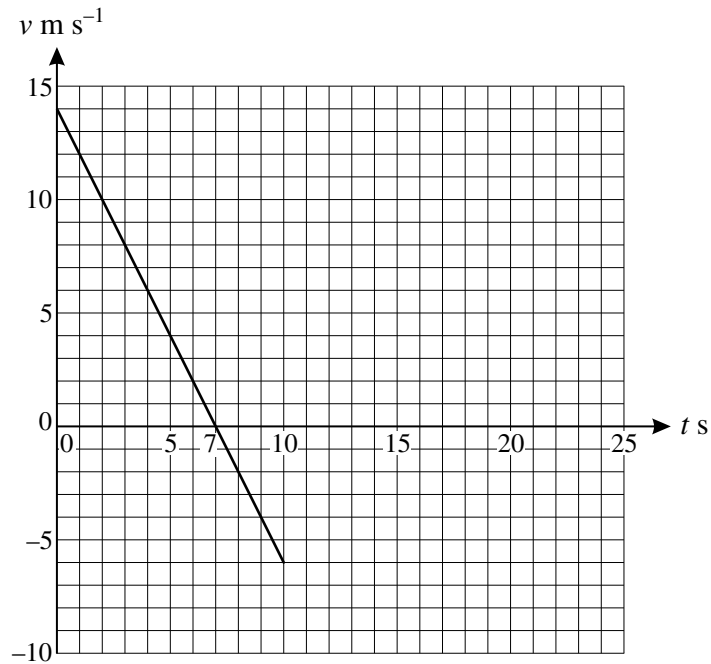


Fig. 1

C then moves as follows.

- In the interval $10 \leq t \leq 15$, the velocity of C is constant at 6 m s^{-1} downwards.
- In the interval $15 \leq t \leq 20$, 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 $0 \leq t \leq 20$. [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 \mathbf{i} and \mathbf{j} which are respectively horizontal and vertically upwards.

The resultant of the two forces is \mathbf{F} N.

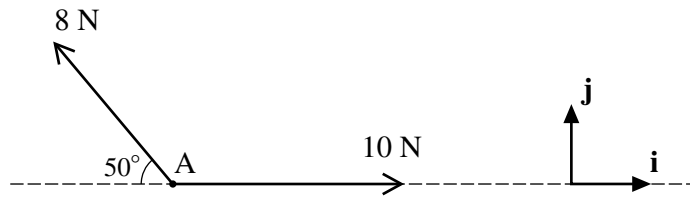


Fig. 2

- (i) Find \mathbf{F} in terms of \mathbf{i} and \mathbf{j} , giving your answer correct to three significant figures. [3]
- (ii) Calculate the magnitude of \mathbf{F} and the angle that \mathbf{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 m s^{-1} ,
- Q is instantaneously at rest and has an acceleration of 4 m 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.

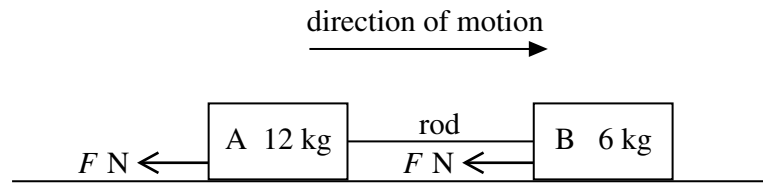


Fig. 5

The boxes have an initial speed of 1.5 m 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.

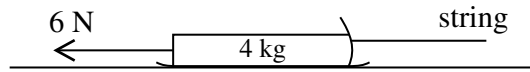


Fig. 6.1

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 m s^{-2} forwards.

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

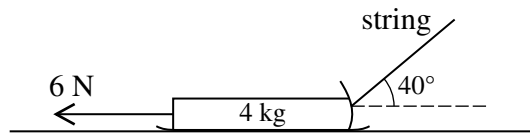


Fig. 6.2

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]

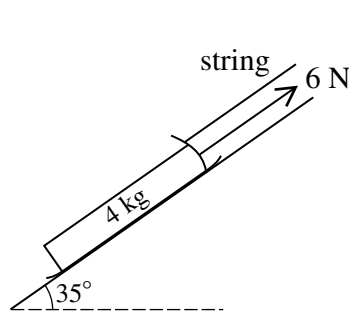


Fig. 6.3

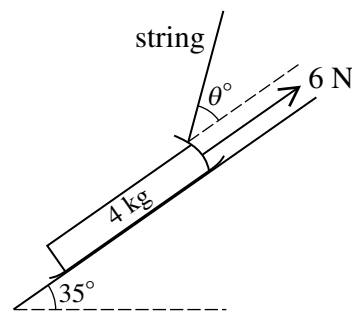


Fig. 6.4

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 θ° 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]

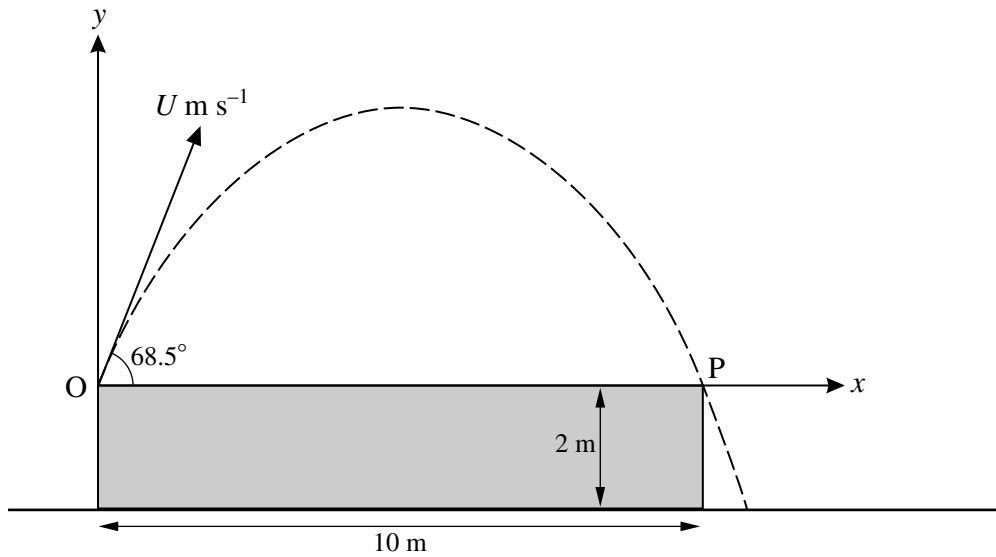


Fig. 7

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 $U \text{ m s}^{-1}$. 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 $T = \frac{U \sin 68.5^\circ}{4.9}$ 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]

BLANK PAGE

**Copyright Information**

OCR is committed to seeking permission to reproduce all third-party content that it uses in its assessment materials. OCR has attempted to identify and contact all copyright holders whose work is used in this paper. To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced in the OCR Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download from our public website (www.ocr.org.uk) after the live examination series.

If OCR has unwittingly failed to correctly acknowledge or clear any third-party content in this assessment material, OCR will be happy to correct its mistake at the earliest possible opportunity.

For queries or further information please contact the Copyright Team, First Floor, 9 Hills Road, Cambridge CB2 1GE.

OCR is part of the Cambridge Assessment Group; Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.