



Thursday 12 June 2014 – Afternoon

AS GCE MATHEMATICS (MEI)

4761/01 Mechanics 1

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:

- Printed Answer Book 4761/01
- MEI Examination Formulae and Tables (MF2)

Other materials required:

- Scientific or graphical calculator

Duration: 1 hour 30 minutes

MODIFIED LANGUAGE



INSTRUCTIONS TO CANDIDATES

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

- The Question Paper will be found inside 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.
- 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 $g \text{ ms}^{-2}$. 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 recycled. Please contact OCR Copyright should you wish to re-use this document.

Section A (36 marks)

- 1 Fig. 1 shows the velocity-time graph of a cyclist travelling along a straight horizontal road between two sets of traffic lights. The velocity, v , is measured in metres per second and the time, t , in seconds. The distance travelled, s metres, is measured from when $t = 0$.

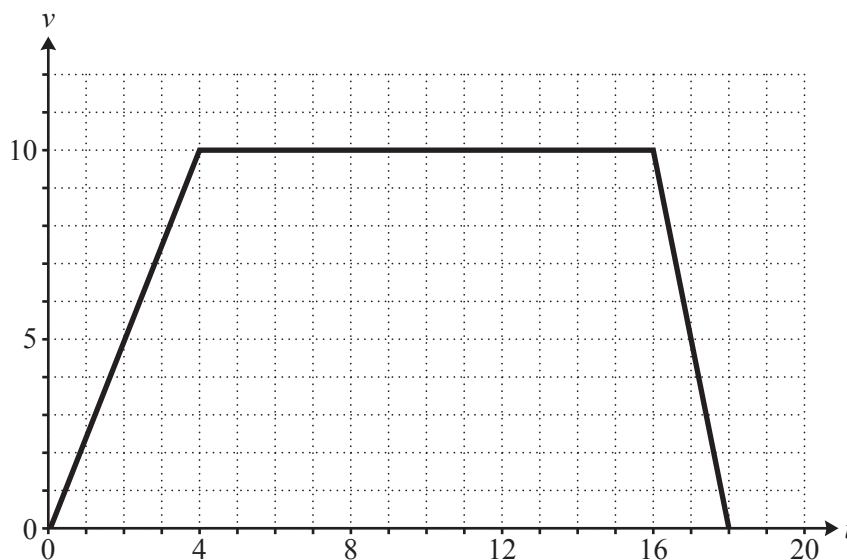


Fig. 1

- (i) Find the values of s when $t = 4$ and when $t = 18$. [3]
- (ii) Sketch the graph of s against t for $0 \leq t \leq 18$. [3]
- 2 The unit vectors \mathbf{i} and \mathbf{j} shown in Fig. 2 are in the horizontal and vertically upwards directions.



Fig. 2

Forces \mathbf{p} and \mathbf{q} are given, in newtons, by $\mathbf{p} = 12\mathbf{i} - 5\mathbf{j}$ and $\mathbf{q} = 16\mathbf{i} + 1.5\mathbf{j}$.

- (i) Write down the force $\mathbf{p} + \mathbf{q}$ and show that it is parallel to $8\mathbf{i} - \mathbf{j}$. [3]
- (ii) Show that the force $3\mathbf{p} + 10\mathbf{q}$ acts in the horizontal direction. [2]
- (iii) A particle is in equilibrium under forces $k\mathbf{p}$, $3\mathbf{q}$ and its weight \mathbf{w} .
Show that the value of k must be -4 and find the mass of the particle. [3]

- 3 Fig. 3 shows a smooth ball resting in a rack. The angle in the middle of the rack is 90° . The rack has one edge at angle α to the horizontal.

The weight of the ball is W N. The reaction forces of the rack on the ball at the points of contact are R N and S N.

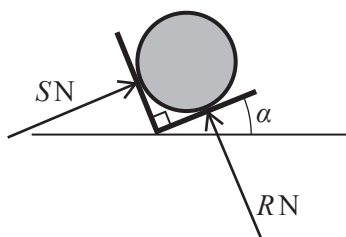


Fig. 3

- (i) Draw a fully labelled triangle of forces to show the forces acting on the ball. Your diagram must indicate which angle is α . [3]
- (ii) Find the values of R and S in terms of W and α . [2]
- (iii) On the same axes draw sketches of R against α and S against α for $0^\circ \leq \alpha \leq 90^\circ$.

For what values of α is $R < S$? [3]

- 4 Fig. 4 illustrates a situation in which a film is being made. A cannon is fired from the top of a vertical cliff towards a ship out at sea. The film director wants the cannon ball to land in the sea just short of the ship so that it appears to be a near-miss. It is important that the ship is not hit by mistake because there are actors on board.

The cannon ball is fired from a height 75 m above the sea with an initial velocity of 20 m s^{-1} at an angle of 30° above the horizontal. The ship is 90 m from the bottom of the cliff.

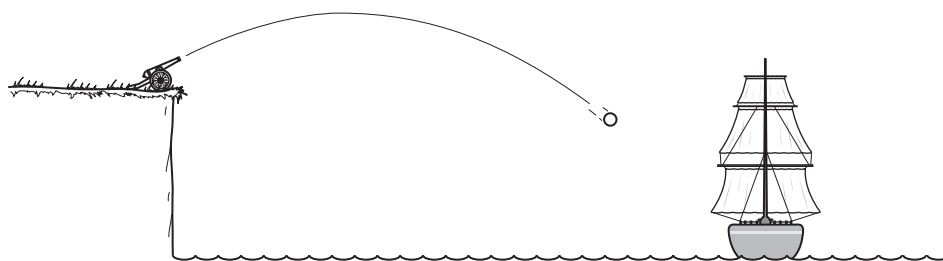


Fig. 4

- (i) The director calculates where the cannon ball will hit the sea using the standard projectile model and taking the value of g to be 10 m s^{-2} .

Verify that according to this model the cannon ball is in the air for 5 seconds. Show that it hits the water less than 5 m from the ship. [6]

- (ii) Without doing any further calculations, state, with a brief reason, whether the cannon ball would be predicted to travel further from the cliff if the value of g were taken to be 9.8 m s^{-2} . [1]

- 5 In a science fiction story a new type of spaceship travels to the moon. The journey takes place along a straight line. The spaceship starts from rest on the earth and arrives at the moon's surface with zero speed. Its speed, v kilometres per hour at time t hours after it has started, is given by

$$v = 37500(4t - t^2).$$

(i) Show that the spaceship takes 4 hours to reach the moon. [1]

(ii) Find an expression for the distance the spaceship has travelled at time t .

Hence find the distance to the moon. [4]

(iii) Find the spaceship's greatest speed during the journey. [2]

Section B (36 marks)

- 6 In this question the origin is a point on the ground. The directions of the unit vectors $\begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$, $\begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$ are east, north and vertically upwards.



Alesha does a sky-dive on a day when there is no wind. The dive starts when she steps out of a moving helicopter. The dive ends when she lands gently on the ground.

- During the dive Alesha can reduce the magnitude of her acceleration in the vertical direction by spreading her arms and increasing air resistance.
- During the dive she can use a power unit strapped to her back to give herself an acceleration in a horizontal direction.
- Alesha's mass, including her equipment, is 100 kg.
- Initially, her position vector is $\begin{pmatrix} -75 \\ 90 \\ 750 \end{pmatrix}$ m and her velocity is $\begin{pmatrix} -5 \\ 0 \\ -10 \end{pmatrix}$ ms⁻¹.

- (i) Calculate Alesha's initial speed, and the initial angle between her motion and the downward vertical. [4]

At a certain time during the dive, forces of $\begin{pmatrix} 0 \\ 0 \\ -980 \end{pmatrix}$ N, $\begin{pmatrix} 0 \\ 0 \\ 880 \end{pmatrix}$ N and $\begin{pmatrix} 50 \\ -20 \\ 0 \end{pmatrix}$ N are acting on Alesha.

- (ii) Suggest how these forces could arise. [3]
- (iii) Find Alesha's acceleration at this time, giving your answer in vector form, and show that its magnitude is 1.14 ms⁻² correct to 3 significant figures. [3]

One suggested model for Alesha's motion is that the forces on her are constant throughout the dive from when she leaves the helicopter until she reaches the ground.

- (iv) Find expressions for her velocity and position vector at time t seconds after the start of the dive according to this model. Verify that when $t = 30$ she is at the origin. [6]
- (v) Explain why consideration of Alesha's landing velocity shows this model to be unrealistic. [2]

- 7 Fig. 7 illustrates a train with a locomotive, L, pulling two trucks, A and B.

The locomotive has mass 90 tonnes and is subject to a resistance force of 2000 N.

Each of the trucks A and B has mass 30 tonnes and is subject to a resistance force of 500 N.

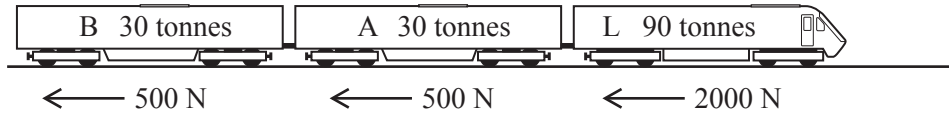


Fig. 7

Initially the train is travelling along a straight horizontal track. The locomotive is exerting a driving force of 12 000 N.

- (i) Find the acceleration of the train. [3]

- (ii) Find the tension in the coupling between trucks A and B. [3]

A fault occurs with truck A when the train is travelling at 10 ms^{-1} . The resistance to the truck's motion changes from 500 N to 5000 N.

The driver reduces the driving force to zero. This allows the train to slow down under the resistance forces and come to a stop.

- (iii) Find the distance the train travels while slowing down and coming to a stop.

Find also the force in the coupling between trucks A and B while the train is slowing down. State whether it is a tension or a thrust. [7]

The fault in truck A is repaired so that the resistance to its motion is again 500 N. The train continues and comes to a place where the track goes up a uniform slope at an angle of α° to the horizontal.

- (iv) When the train is on the slope, it travels at uniform speed. The driving force remains at 12 000 N. Find the value of α . [3]

- (v) Show that the force in the coupling between trucks A and B has the same value that it had in part (ii). [2]

END OF QUESTION PAPER

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