

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
AS GCE
4761
MATHEMATICS (MEI)
Mechanics 1
QUESTION PAPER

FRIDAY 1 JUNE 2012: Morning
DURATION: 1 hour 30 minutes
plus your additional time allowance

MODIFIED ENLARGED

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
MEI Examination Formulae and Tables (MF2)
Insert for question 8(iii)

OTHER MATERIALS REQUIRED:

Scientific or graphical calculator

READ INSTRUCTIONS OVERLEAF

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.**
- **Answer ALL the questions.**
- **Read each question carefully. Make sure you know what you have to do before starting your answer.**
- **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.**

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 the speed-time graph of a runner during part of his training.

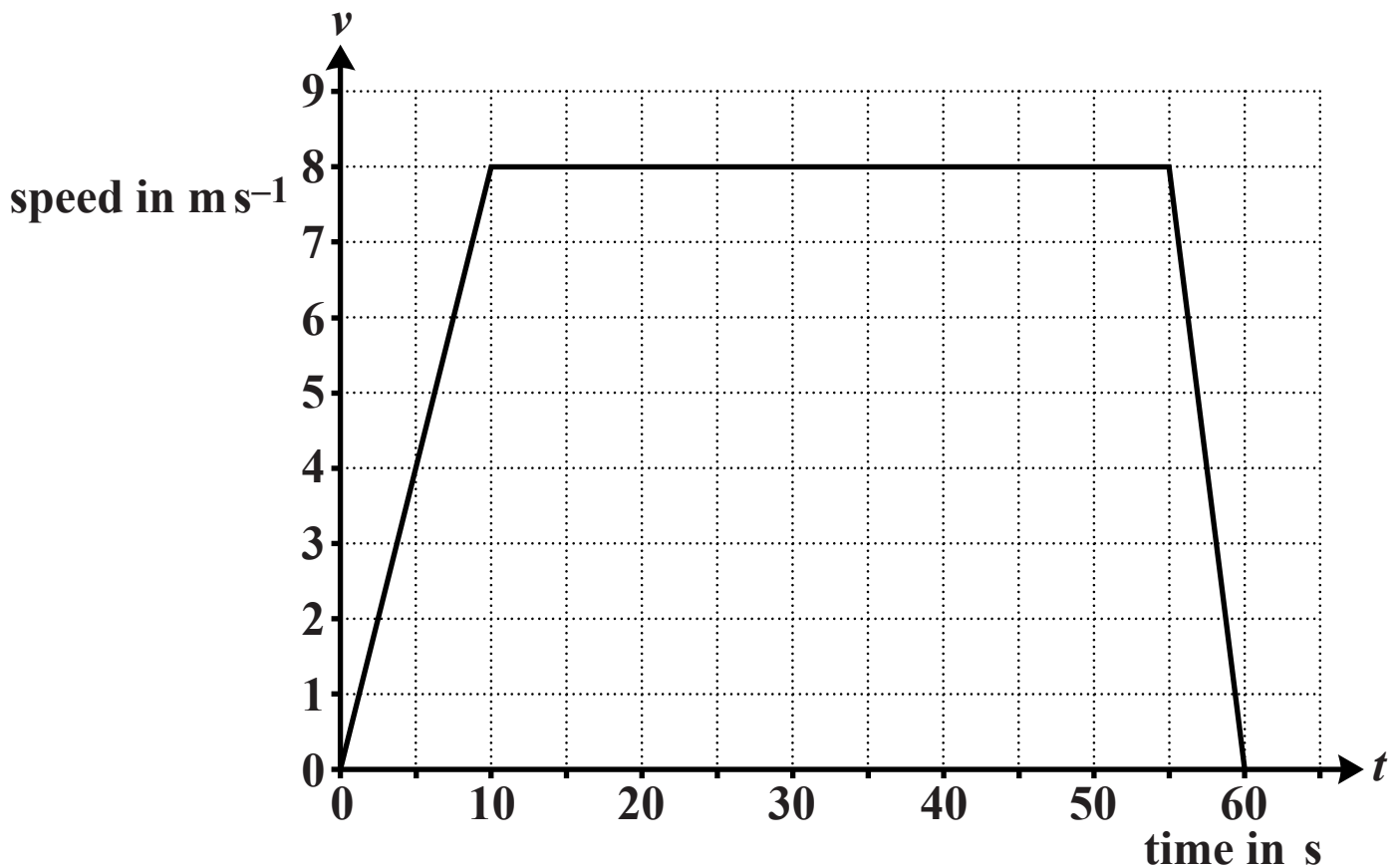


Fig. 1

For each of the following statements, say whether it is true or false. If it is false give a brief explanation.

- (A) The graph shows that the runner finishes where he started.
- (B) The runner's maximum speed is 8 m s^{-1} .
- (C) At time 58 seconds, the runner is slowing down at a rate of 1.6 m s^{-2} .
- (D) The runner travels 400 m altogether. [6]

- 2** A particle is moving along a straight line and its position is relative to an origin on the line. At time t s, the particle's acceleration, $a \text{ m s}^{-2}$, is given by

$$a = 6t - 12 .$$

At $t = 0$ the velocity of the particle is $+9 \text{ m s}^{-1}$ and its position is -2 m .

- (i) Find an expression for the velocity of the particle at time t s and verify that it is stationary when $t = 3$. [4]
- (ii) Find the position of the particle when $t = 2$. [3]

- 3** The vectors P , Q and R are given by

$$P = 5i + 4j, \quad Q = 3i - 5j, \quad R = -8i + j.$$

- (i) Find the vector $P + Q + R$. [1]
- (ii) Interpret your answer to part (i) in the cases
 - (A) P , Q and R represent three forces acting on a particle, [1]
 - (B) P , Q and R represent three stages of a hiker's walk. [1]

- 4 Fig. 4 below illustrates points A, B and C on a straight race track. The distance AB is 300 m and AC is 500 m.



Fig. 4

A car is travelling along the track with uniform acceleration.

Initially the car is at A and travelling in the direction AB with speed 5 m s^{-1} . After 20 s it is at C.

- (i) Find the acceleration of the car. [2]
- (ii) Find the speed of the car at B and how long it takes to travel from A to B. [3]

- 5 Fig. 5 below shows a block of mass 10 kg at rest on a rough horizontal floor. A light string, at an angle of 30° to the vertical, is attached to the block. The tension in the string is 50 N.

The block is in equilibrium.

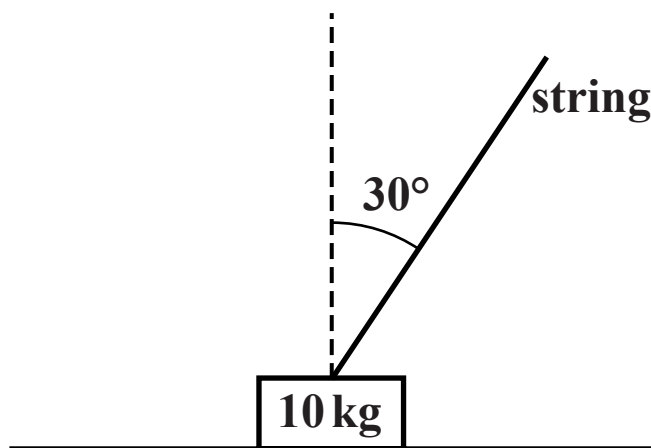


Fig. 5

- (i) Show all the forces acting on the block. [2]
- (ii) Show that the frictional force acting on the block is 25 N. [2]
- (iii) Calculate the normal reaction of the floor on the block. [2]
- (iv) Calculate the magnitude of the total force the floor is exerting on the block. [2]

- 6 A football is kicked with speed 31 m s^{-1} at an angle of 20° to the horizontal. It travels towards the goal which is 50 m away. The height of the crossbar of the goal is 2.44 m.**

- (i) Does the ball go over the top of the crossbar? Justify your answer. [6]**
- (ii) State one assumption that you made in answering part (i). [1]**

SECTION B (36 marks)

- 7 A train consists of a locomotive pulling 17 identical trucks.**

The mass of the locomotive is 120 tonnes and the mass of each truck is 40 tonnes. The locomotive gives a driving force of 121 000 N.

The resistance to motion on each truck is $R \text{ N}$ and the resistance on the locomotive is $5R \text{ N}$.

Initially the train is travelling on a straight horizontal track and its acceleration is 0.11 m s^{-2} .

- (i) Show that $R = 1500$. [4]**
- (ii) Find the tensions in the couplings between**
- (A) the last two trucks, [4]**
- (B) the locomotive and the first truck. [3]**

The train now comes to a place where the track goes up a straight, uniform slope at an angle α with the horizontal, where $\sin \alpha = \frac{1}{80}$.

The driving force and the resistance forces remain the same as before.

- (iii) Find the magnitude and direction of the acceleration of the train. [4]**

The train then comes to a straight uniform downward slope at an angle β to the horizontal.

The driver of the train reduces the driving force to zero and the resistance forces remain the same as before.

The train then travels at a constant speed down the slope.

- (iv) Find the value of β . [3]**

- 8 In this question, positions are given relative to a fixed origin, O. The x -direction is east and the y -direction north; distances are measured in kilometres.**

Two boats, the Rosemary and the Sage, are having a race between two points A and B.

The position vector of the Rosemary at time t hours after the start is given by

$$\mathbf{r} = \begin{pmatrix} 3 \\ 2 \end{pmatrix} + \begin{pmatrix} 6 \\ 8 \end{pmatrix} t, \text{ where } 0 \leq t \leq 2.$$

The Rosemary is at point A when $t = 0$, and at point B when $t = 2$.

- (i) Find the distance AB. [3]**
- (ii) Show that the Rosemary travels at constant velocity. [1]**

The position vector of the Sage is given by

$$\mathbf{r} = \begin{pmatrix} 3(2t + 1) \\ 2(2t^2 + 1) \end{pmatrix}.$$

- (iii) On the grid provided plot the points A and B.**

Draw the paths of the two boats for $0 \leq t \leq 2$. [3]

- (iv) What can you say about the result of the race? [1]**
- (v) Find the speed of the Sage when $t = 2$. Find also the direction in which it is travelling, giving your answer as a compass bearing, to the nearest degree. [6]**

- (vi) Find the displacement of the Rosemary from the Sage at time t and hence calculate the greatest distance between the boats during the race. [4]**

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