OCR
RECOGNISING ACHIEVEMENT

Friday 1 June 2012 – Morning

AS 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

Duration: 1 hour 30 minutes

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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.
- 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

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.

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Section A (36 marks)

1 Fig. 1 shows the speed-time graph of a runner during part of his training.

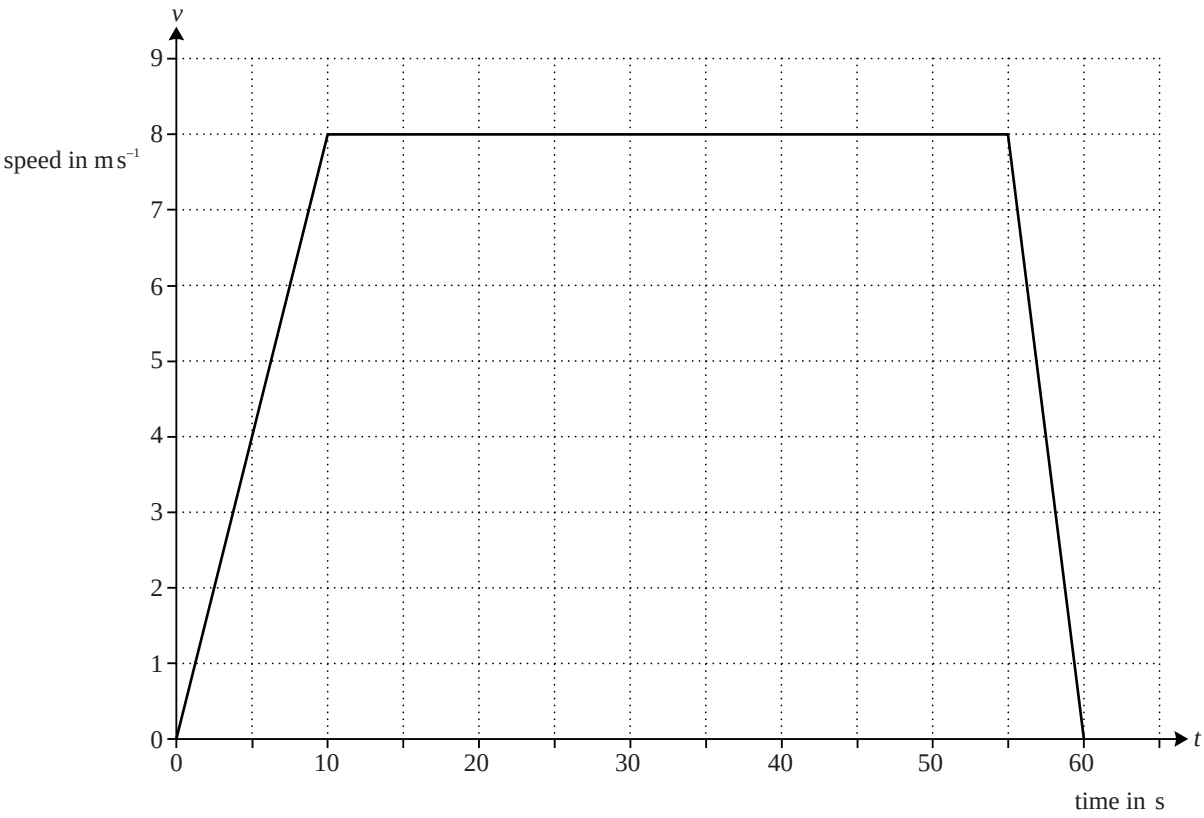

Fig. 1

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 $8\,\mathrm{m\,s^{-1}}$.

(*C*) At time 58 seconds, the runner is slowing down at a rate of $1.6\,\mathrm{m\,s^{-2}}$.

(*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, $a\ \mathrm{m\,s^{-2}}$, is given by

$$a = 6t - 12\ .$$

At $t = 0$ the velocity of the particle is $+9\,\mathrm{m\,s^{-1}}$ 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]**

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

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

(i) Find the vector $\mathbf{P} + \mathbf{Q} + \mathbf{R}$. **[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 illustrates points A, B and C on a straight race track. The distance AB is 300 m and AC is 500 m.

A car is travelling along the track with uniform acceleration.

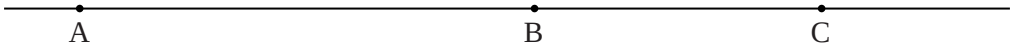

Fig. 4

Initially the car is at A and travelling in the direction AB with speed $5\,\text{m}\,\text{s}^{-1}$. 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 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.

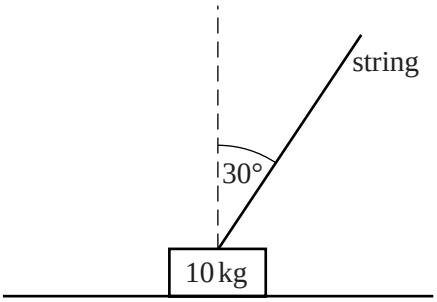

Fig. 5

(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]**

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6 A football is kicked with speed $31\,\text{m}\,\text{s}^{-1}$ 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 N and the resistance on the locomotive is $5R$ N.

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

(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]**

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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

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

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) Plot the points A and B.

Draw the paths of the two boats for $0 \leqslant t \leqslant 2$. **[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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