OCR
RECOGNISING ACHIEVEMENT

**ADVANCED SUBSIDIARY GCE UNIT** **4761/01**

# MATHEMATICS (MEI)

Mechanics 1

**MONDAY 21 MAY 2007**

Morning
Time: 1 hour 30 minutes

Additional materials:
Answer booklet (8 pages)
Graph paper
MEI Examination Formulae and Tables (MF2)

**INSTRUCTIONS TO CANDIDATES**

- Write your name, centre number and candidate number in the spaces provided on the answer booklet.
- Answer **all** the questions.
- You are permitted to use a 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 $g$ m s$^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

**INFORMATION FOR CANDIDATES**

- The number of marks is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is 72.

**ADVICE TO CANDIDATES**

- Read each question carefully and make sure you know what you have to do before starting your answer.
- 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.



**[Turn over**

**Section A** (36 marks)

**1** Fig. 1 shows four forces in equilibrium.

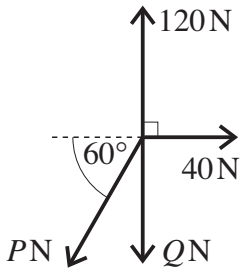


**Fig. 1**

**(i)** Find the value of $P$. [3]

**(ii)** Hence find the value of $Q$. [2]

**2** A car passes a point A travelling at 10 m s$^{-1}$. Its motion over the next 45 seconds is modelled as follows.

- The car's speed increases uniformly from 10 m s$^{-1}$ to 30 m s$^{-1}$ over the first 10 s.
- Its speed then increases uniformly to 40 m s$^{-1}$ over the next 15 s.
- The car then maintains this speed for a further 20 s at which time it reaches the point B.

**(i)** Sketch a speed-time graph to represent this motion. [3]

**(ii)** Calculate the distance from A to B. [3]

**(iii)** When it reaches the point B, the car is brought uniformly to rest in $T$ seconds. The total distance from A is now 1700 m. Calculate the value of $T$. [2]

**3** Fig. 3 shows a system in equilibrium. The rod is firmly attached to the floor and also to an object, P. The light string is attached to P and passes over a smooth pulley with an object Q hanging freely from its other end.

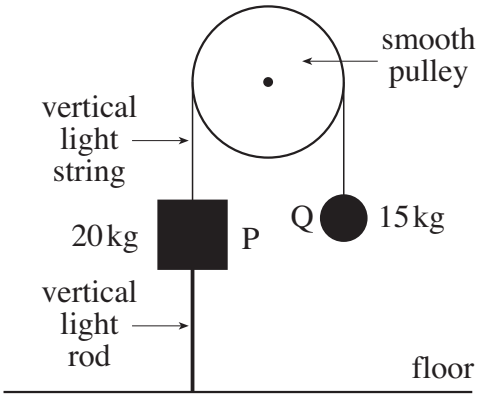


**Fig. 3**

**(i)** Why is the tension the same throughout the string? [1]

**(ii)** Calculate the force in the rod, stating whether it is a tension or a thrust. [3]

**4** Two trucks, A and B, each of mass 10 000 kg, are pulled along a straight, horizontal track by a constant, horizontal force of $P$ N. The coupling between the trucks is light and horizontal. This situation and the resistances to motion of the trucks are shown in Fig. 4.

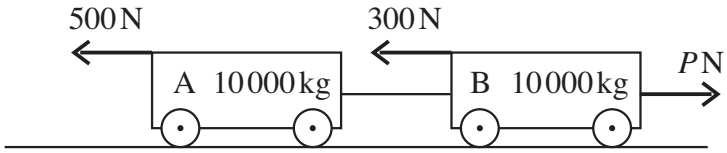


**Fig. 4**

The acceleration of the system is 0.2 m s$^{-2}$ in the direction of the pulling force of magnitude $P$.

**(i)** Calculate the value of $P$. [3]

Truck A is now subjected to an extra resistive force of 2000 N while $P$ does not change.

**(ii)** Calculate the new acceleration of the trucks. [2]

**(iii)** Calculate the force in the coupling between the trucks. [2]



**[Turn over**

**5** A block of weight 100 N is on a rough plane that is inclined at 35° to the horizontal. The block is in equilibrium with a horizontal force of 40 N acting on it, as shown in Fig. 5.

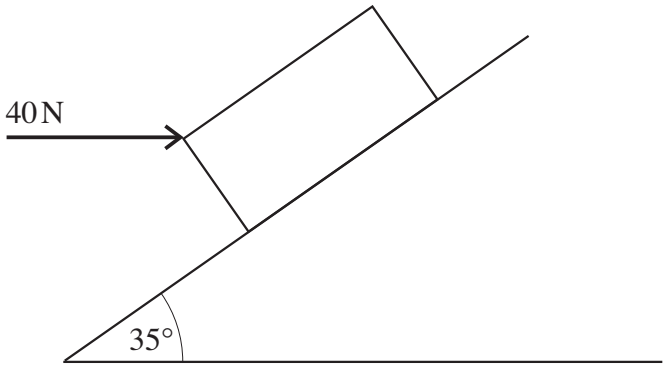


**Fig. 5**

Calculate the frictional force acting on the block. [4]

**6** A rock of mass 8 kg is acted on by just the two forces $-80\mathbf{k}$ N and $(-\mathbf{i} + 16\mathbf{j} + 72\mathbf{k})$ N, where **i** and **j** are perpendicular unit vectors in a horizontal plane and **k** is a unit vector vertically upward.

**(i)** Show that the acceleration of the rock is $\left(-\frac{1}{8}\mathbf{i} + 2\mathbf{j} - \mathbf{k}\right)\text{m s}^{-2}$. [2]

The rock passes through the origin of position vectors, O, with velocity $(\mathbf{i} - 4\mathbf{j} + 3\mathbf{k})$ m s$^{-1}$ and 4 seconds later passes through the point A.

**(ii)** Find the position vector of A. [3]

**(iii)** Find the distance OA. [1]

**(iv)** Find the angle that OA makes with the horizontal. [2]

**Section B** (36 marks)

**7** Fig. 7 is a sketch of part of the velocity-time graph for the motion of an insect walking in a straight line. Its velocity, $v$ m s$^{-1}$, at time $t$ seconds for the time interval $-3 \leqslant t \leqslant 5$ is given by

$$v = t^2 - 2t - 8.$$

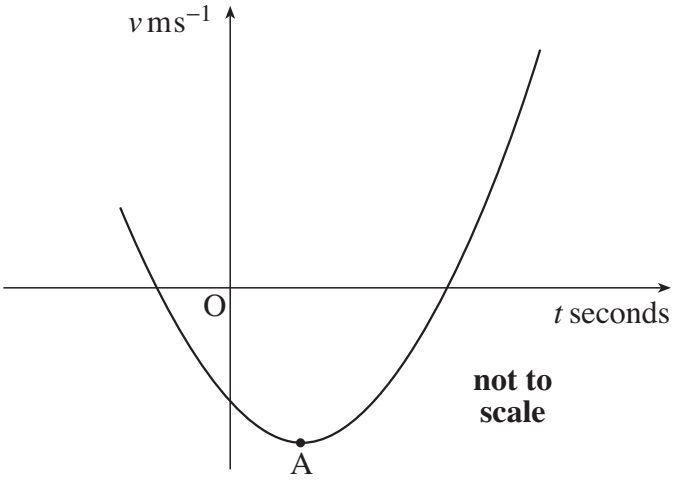


**Fig. 7**

**(i)** Write down the velocity of the insect when $t = 0$. [1]

**(ii)** Show that the insect is instantaneously at rest when $t = -2$ and when $t = 4$. [2]

**(iii)** Determine the velocity of the insect when its acceleration is zero.

Write down the coordinates of the point A shown in Fig. 7. [5]

**(iv)** Calculate the distance travelled by the insect from $t = 1$ to $t = 4$. [5]

**(v)** Write down the distance travelled by the insect in the time interval $-2 \leqslant t \leqslant 4$. [1]

**(vi)** How far does the insect walk in the time interval $1 \leqslant t \leqslant 5$? [3]



**[Turn over**

**8** A ball is kicked from ground level over horizontal ground. It leaves the ground at a speed of $25\,\text{m s}^{-1}$ and at an angle $\theta$ to the horizontal such that $\cos\theta = 0.96$ and $\sin\theta = 0.28$.

**(i)** Show that the height, $y$ m, of the ball above the ground $t$ seconds after projection is given by $y = 7t - 4.9t^2$. Show also that the horizontal distance, $x$ m, travelled by this time is given by $x = 24t$. [3]

**(ii)** Calculate the maximum height reached by the ball. [2]

**(iii)** Calculate the times at which the ball is at half its maximum height.

Find the horizontal distance travelled by the ball between these times. [4]

**(iv)** Determine the following when $t = 1.25$.

(*A*) The vertical component of the velocity of the ball.

(*B*) Whether the ball is rising or falling. (You should give a reason for your answer.)

(*C*) The speed of the ball. [5]

**(v)** Show that the equation of the trajectory of the ball is

$$y = \frac{0.7x}{576}(240 - 7x).$$

Hence, or otherwise, find the range of the ball. [5]