OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MATHEMATICS 2637

Mechanics 1

Thursday **23 MAY 2002** Afternoon 1 hour 20 minutes

Additional materials:
Answer booklet
Graph paper
List of Formulae (MF8)

TIME 1 hour 20 minutes

INSTRUCTIONS TO CANDIDATES

- Write your Name, Centre Number and Candidate Number in the spaces provided on the answer booklet.
- Answer **all** the questions.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.
- Where a numerical value for the acceleration due to gravity is needed, use $9.8\,\text{m}\,\text{s}^{-2}$.
- You are permitted to use a graphic calculator in this paper.

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 60.
- Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.
- **You are reminded of the need for clear presentation in your answers.**

This question paper consists of 4 printed pages.

Registered Charity Number: 1066969
[Turn over

1

An engine pulls a truck of mass 6000 kg along a straight horizontal track, exerting a constant horizontal force of magnitude E newtons on the truck (see diagram). The resistance to motion of the truck has magnitude 400 N, and the acceleration of the truck is $0.2\,\text{m s}^{-2}$. Find the value of E. [4]

2

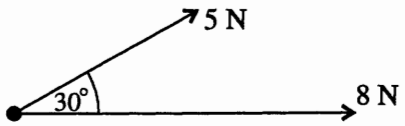


Fig. 1

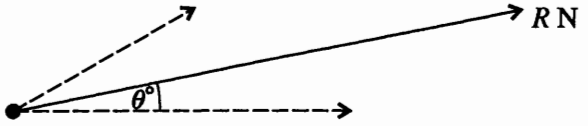
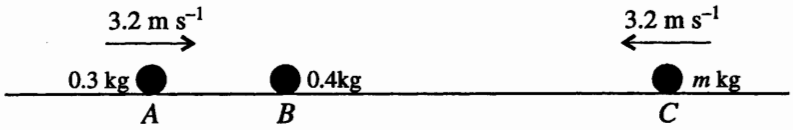


Fig. 2

Forces of magnitudes 8 N and 5 N act on a particle. The angle between the directions of the two forces is 30°, as shown in Fig. 1. The resultant of the two forces has magnitude R N and acts at an angle $\theta°$ to the force of magnitude 8 N, as shown in Fig. 2. Find R and θ. [7]

3



Three uniform spheres A, B and C have masses 0.3 kg, 0.4 kg and m kg respectively. The spheres lie in a smooth horizontal groove with B between A and C. Sphere B is at rest and spheres A and C are each moving with speed $3.2\,\text{m s}^{-1}$ towards B (see diagram). Air resistance may be ignored.

(i) A collides with B. After this collision A continues to move in the same direction as before, but with speed $0.8\,\text{m s}^{-1}$. Find the speed with which B starts to move. [4]

(ii) B and C then collide, after which they both move towards A, with speeds of $3.1\,\text{m s}^{-1}$ and $0.4\,\text{m s}^{-1}$ respectively. Find the value of m. [4]

4 A particle is projected vertically upwards, from the ground, with a speed of $28\,\text{m s}^{-1}$. Ignoring air resistance, find

(i) the maximum height reached by the particle, [2]

(ii) the speed of the particle when it is 30 m above the ground, [3]

(iii) the time taken for the particle to fall from its highest point to a height of 30 m, [3]

(iv) the length of time for which the particle is more than 30 m above the ground. [1]

5 A particle P moves in a straight line so that, at time t seconds after leaving a fixed point O, its acceleration is $-\frac{1}{10}t\,\mathrm{m\,s^{-2}}$. At time $t = 0$, the velocity of P is $V\,\mathrm{m\,s^{-1}}$.

(i) Find, by integration, an expression in terms of t and V for the velocity of P. [3]

(ii) Find the value of V, given that P is instantaneously at rest when $t = 10$. [2]

(iii) Find the displacement of P from O when $t = 10$. [4]

6

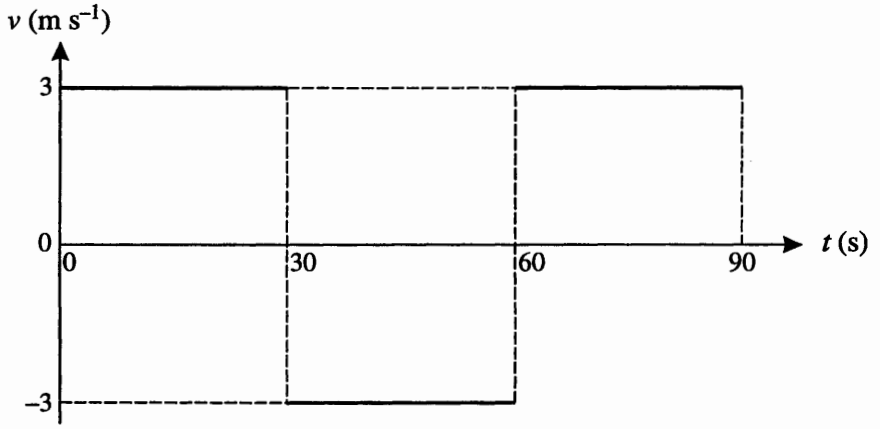


Fig. 1

A woman runs from A to B, then from B to A and then from A to B again, on a straight track, taking 90 s. The woman runs at a constant speed throughout. Fig. 1 shows the (t, v) graph for the woman.

(i) Find the total distance run by the woman. [2]

(ii) Find the distance of the woman from A when $t = 50$ and when $t = 80$. [3]

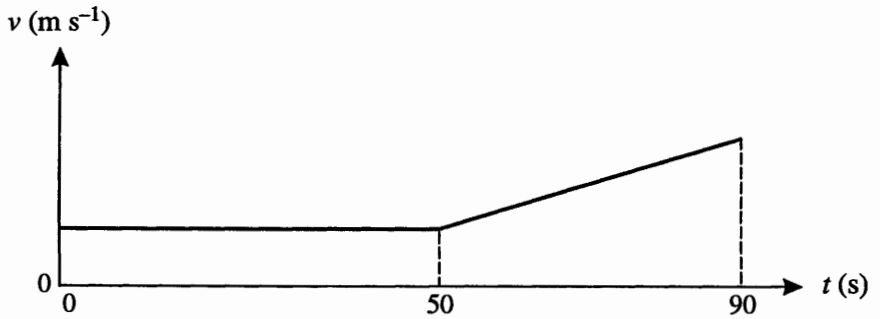


Fig. 2

At time $t = 0$, a child also starts to move, from A, along AB. The child walks at a constant speed for the first 50 s and then at an increasing speed for the next 40 s. Fig. 2 shows the (t, v) graph for the child; it consists of two straight line segments.

(iii) At time $t = 50$, the woman and child pass each other, moving in opposite directions. Find the speed of the child during the first 50 s. [3]

(iv) At time $t = 80$, the woman overtakes the child. Find the speed of the child at this instant. [3]

[Turn over

7 A sledge of mass 25 kg is on a plane inclined at 30° to the horizontal. The coefficient of friction between the sledge and the plane is 0.2.

(i)

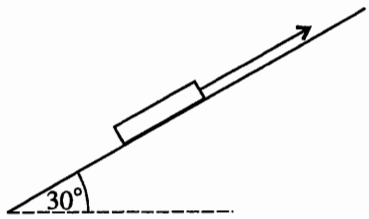


Fig. 1

The sledge is pulled up the plane, with constant acceleration, by means of a light cable which is parallel to a line of greatest slope (see Fig. 1). The sledge starts from rest and acquires a speed of $0.8\,\mathrm{m\,s^{-1}}$ after being pulled for 10 s. Ignoring air resistance, find the tension in the cable. [6]

(ii)

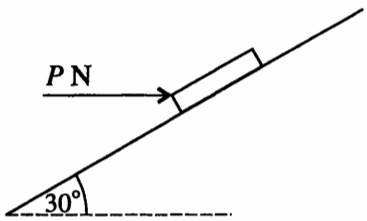


Fig. 2

On a subsequent occasion the cable is not in use and two people of total mass 150 kg are seated in the sledge. The sledge is held at rest by a horizontal force of magnitude P newtons, as shown in Fig. 2. Find the least value of P which will prevent the sledge from sliding down the plane. [6]

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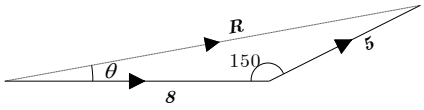
1 N2 $\rightarrow$ $E - 400 = 6000 \times 0 \cdot 2$ $E = \mathbf{1600}$

[4]

2



Cosine Rule

$R^2 = 8^2 + 5^2 - 2 \times 8 \times 5 \times \cos 150^\circ = 158 \cdot 2820...$

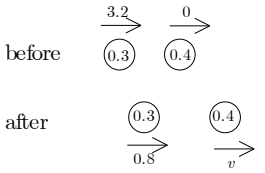
$R = 12 \cdot 5810... = \mathbf{12 \cdot 6}$

Sine Rule

$$\frac{\sin\theta}{5} = \frac{\sin 150^\circ}{12 \cdot 5810...} \qquad \sin\theta = 0 \cdot 1987.... \qquad \theta = 11 \cdot 4616... = \mathbf{11 \cdot 5^\circ}$$

[7]

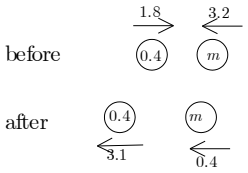
3



conservation of momentum ....

$3 \cdot 2 \times 0 \cdot 3 + 0 = 0 \cdot 8 \times 0 \cdot 3 + 0 \cdot 4v$ $v = \mathbf{1 \cdot 8\ ms^{-1}}$

[4]



$0 \cdot 4 \times 1 \cdot 8 + m \times {}^-3 \cdot 2 = 0 \cdot 4 \times {}^-3 \cdot 1 + m \times {}^-0 \cdot 4$

$1 \cdot 96 = 2 \cdot 8m$

$m = \mathbf{0 \cdot 7}$

[4]

4 taking 'up' as positive....

$v^2 = u^2 + 2as$

$0 = 28^2 - 2 \times 9 \cdot 8 \times h_{max}$

$h_{max} = \mathbf{40\ m}$

[2]

when 30 m above ground ...

$v^2 = u^2 + 2as$

$v^2 = 28^2 - 19 \cdot 6 \times 30 = 196$ speed $= \mathbf{14\ ms^{-1}}$

[3]

time from top to 30 m ...

$v = u + at$ $t = \frac{v - u}{a} = \frac{14 - 0}{9 \cdot 8} = \frac{10}{7}\ \mathbf{s}$

[3]

time above 30 m $= 2 \times \frac{10}{7} = \frac{20}{7} = \mathbf{2\frac{6}{7}\ s}$

[1]

5 $v = \int -\frac{1}{10}t \ \mathrm{d}t = -\frac{1}{20}t^2 + c = \boldsymbol{V - \frac{1}{20}t^2}$

[3]

$v\ 10 = 0 \quad \Rightarrow \quad V - \frac{1}{20}\times 10^2 = 0 \quad \Rightarrow \quad V = \mathbf{5}$

[2]

$s = \int_0^{10} v\,\mathrm{d}t = \int_0^{10} 5 - \frac{1}{20}t^2 \ \mathrm{d}t = \left[5t - \frac{1}{60}t^3\right]_0^{10} = 50 - \frac{100}{6} = \mathbf{33\frac{1}{3}\ m}$

[4]

6 total distance run by woman = 90 x 3 = **270 m**

[2]

$\underline{t = 50}$ distance from A = 10 x 3 = **30 m**

$\underline{t = 80}$ distance from A = 20 x 3 = **60 m**

[3]

speed of child in 1st phase $= {}^{30}\!/_{50} = \mathbf{0 \cdot 6\ ms^{-1}}$

[3]

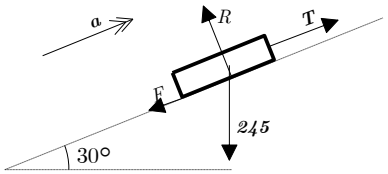
at t = 80, child has covered 60 m in total; that is, 30m in 2nd phase.

for the first 30 s of 2nd phase .....

$s = \left(\frac{u+v}{2}\right)t \quad \Rightarrow \quad 30 = \left(\frac{0 \cdot 6 + v}{2}\right)30 \quad \Rightarrow \quad v = \mathbf{1 \cdot 4\ ms^{-1}}$

[3]

7



$v = u + at \qquad a = \frac{v-u}{t} = \frac{0 \cdot 8}{10} = 0 \cdot 08$

N2 normal to slope $\quad R - 245\cos 30^\circ = 0$

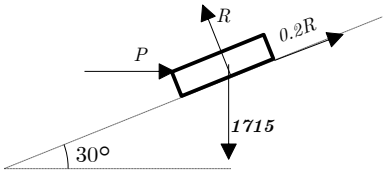
$R = 212 \cdot 1762...$

limiting friction ... $\quad F = \mu R = 42 \cdot 4352...$

N2 up the slope $\quad T - 42 \cdot 4352 - 245\sin 30^\circ = 25 \times 0 \cdot 08$

$T = 166 \cdot 935... = \mathbf{167\ N}$

[6]



N2 parallel $\quad 0 = 2R - P\cos 30^\circ - 1715\sin 30^\circ \quad 0$

N2 normal $\quad R - P\sin 30^\circ - 1715\cos 30^\circ = 0$

$P = \dfrac{1715\ \ 5\sin 30^\circ \ \ \cos 30^\circ}{\sin 30^\circ + 5\cos 30^\circ} = 580 \cdot 1641... = \mathbf{580}\ (3\ \text{s.f.})$

[6]

Total [60]