Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						6	6	7	7	/	0	1	Signature	

Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Advanced/Advanced Subsidiary

Thursday 12 January 2006 – Afternoon

Time: 1 hour 30 minutes

Examiner's use only		

Team Leader's use only		

Question Number	Leave Blank
1	
2	
3	
4	
5	
6	
7	
Total	

Materials required for examination
Mathematical Formulae (Green or Lilac)

Items included with question papers
Nil

Candidates may use any calculator EXCEPT those with the facility for symbolic algebra, differentiation and/or integration. Thus candidates may NOT use calculators such as the Texas Instruments TI 89, TI 92, Casio CFX 9970G, Hewlett Packard HP 48G.

Solutions

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature.
Check that you have the correct question paper.
You must write your answers to each question in the spaces following the question.
Whenever a numerical value of g is required, take $g = 9.8 \text{ m s}^{-2}$.
When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information for Candidates

A booklet 'Mathematical Formulae and Statistical Tables' is provided.
Full marks may be obtained for answers to ALL questions.
The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
There are 7 questions in this question paper. The total mark for this paper is 75.
There are 20 pages in this question paper. Any blank pages are indicated.

Advice to Candidates

You must ensure that your answers to parts of questions are clearly labelled.
You must show sufficient working to make your methods clear to the examiner. Answers without working may gain no credit.

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1. A stone is thrown vertically upwards with speed 16 m s^{-1} from a point h metres above the ground. The stone hits the ground 4 s later. Find

(a) the value of h,

(3)

(b) the speed of the stone as it hits the ground.

(3)

a)

$s - s_0 = ut + \frac{1}{2}at^2$

$0 - h = 16 \times 4 - 4.9 \times 4^2$

$4.9 \times 16 - 64 = h$

$h = 14.4\ m$

b)

$v = u + at$

$v = 16 - 9.8 \times 4$

$v = -23.2\ ms^{-1}$

Speed $= 23.2\ ms^{-1}$

THIS QUESTION NOW FURTHER MATHS ONLY

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2. (a) Two particles A and B, of mass 3 kg and 2 kg respectively, are moving in the same direction on a smooth horizontal table when they collide directly. Immediately before the collision, the speed of A is 4 m s^{-1} and the speed of B is 1.5 m s^{-1}. In the collision, the particles join to form a single particle C.

Find the speed of C immediately after the collision.

(3)

(b) Two particles P and Q have mass 3 kg and m kg respectively. They are moving towards each other in opposite directions on a smooth horizontal table. Each particle has speed 4 m s^{-1}, when they collide directly. In this collision, the direction of motion of each particle is reversed. The speed of P immediately after the collision is 2 m s^{-1} and the speed of Q is 1 m s^{-1}. Find

(i) the value of m,

(3)

(ii) the magnitude of the impulse exerted on Q in the collision.

(2)

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Question 2 continued

Q2

(Total 8 marks)

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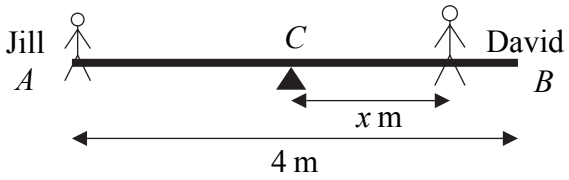
3. **Figure 1**



A seesaw in a playground consists of a beam AB of length 4 m which is supported by a smooth pivot at its centre C. Jill has mass 25 kg and sits on the end A. David has mass 40 kg and sits at a distance x metres from C, as shown in Figure 1. The beam is initially modelled as a uniform rod. Using this model,

(a) find the value of x for which the seesaw can rest in equilibrium in a horizontal position.

(3)

(b) State what is implied by the modelling assumption that the beam is uniform.

(1)

David realises that the beam is not uniform as he finds that he must sit at a distance 1.4 m from C for the seesaw to rest horizontally in equilibrium. The beam is now modelled as a non-uniform rod of mass 15 kg. Using this model,

(c) find the distance of the centre of mass of the beam from C.

(4)

a) Moments about C

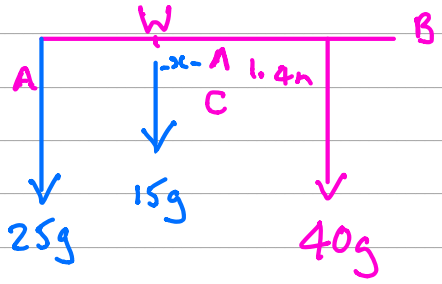
$25g \times 2 = 40g \times x$

$\frac{50}{40} = x$

$x = 1.25$

b) Centre of mass is at midpoint of AB

c)



Moments about C

$25g \times 2 + 15g \times x = 40g \times 1.4$

$50 + 15x = 56$

Leave blank

Question 3 continued

$15x = 6$

$x = \frac{6}{15}$

$x = 0.4\,m$

Q3

(Total 8 marks)

Leave blank

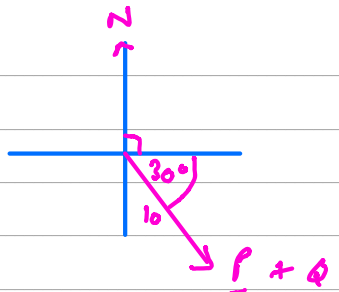
4. Two forces **P** and **Q** act on a particle. The force **P** has magnitude 7 N and acts due north. The resultant of **P** and **Q** is a force of magnitude 10 N acting in a direction with bearing 120°. Find

(i) the magnitude of **Q**,

(ii) the direction of **Q**, giving your answer as a bearing.

(9)

i) $\underline{P} + \underline{Q} = \begin{pmatrix} 10\cos 30^\circ \\ -10\sin 30^\circ \end{pmatrix}$



$\begin{pmatrix} 0 \\ 7 \end{pmatrix} + \underline{Q} = \begin{pmatrix} 5\sqrt{3} \\ -5 \end{pmatrix}$

$\underline{Q} = \begin{pmatrix} 5\sqrt{3} \\ -5 \end{pmatrix} - \begin{pmatrix} 0 \\ 7 \end{pmatrix} = \begin{pmatrix} 5\sqrt{3} \\ -12 \end{pmatrix}$

$|\underline{Q}| = \sqrt{(5\sqrt{3})^2 + (-12)^2} = 14.8 \text{ N}$

ii)

$\alpha = \tan^{-1}\left(\frac{12}{5\sqrt{3}}\right) = 54.2^\circ$

Direction of $\underline{Q}$

144.2°

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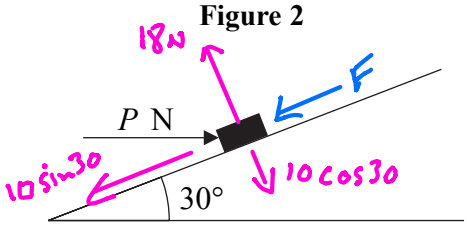
5.

Figure 2



A parcel of weight 10 N lies on a rough plane inclined at an angle of 30° to the horizontal. A horizontal force of magnitude P newtons acts on the parcel, as shown in Figure 2. The parcel is in equilibrium and on the point of slipping up the plane. The normal reaction of the plane on the parcel is 18 N. The coefficient of friction between the parcel and the plane is μ. Find

(a) the value of P,

(4)

(b) the value of μ.

(5)

The horizontal force is removed.

(c) Determine whether or not the parcel moves.

(5)

a) ⊥ to slope

$$P\sin 30^\circ + 10\cos 30^\circ = 18$$

$$P = \frac{18 - 10\cos 30^\circ}{\sin 30^\circ}$$

$$P = 18.7 \text{ N}$$

b) ∥ to slope

$$P\cos 30^\circ = 10\sin 30^\circ + F$$

$$18.679\cos 30 - 10\sin 30 = 18\mu$$

$$\mu = \frac{18.679\cos 30^\circ - 10\sin 30^\circ}{18} = 0.621$$

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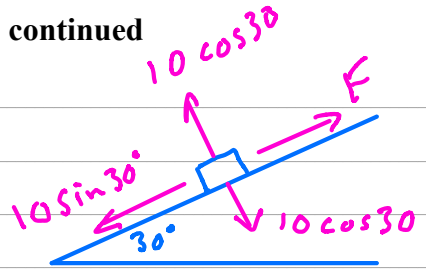
Question 5 continued

c)



Max friction $= \mu R = 0.621 \times 10\cos 30°$

$\Rightarrow 5.38\ N$

$10 \sin 30° = 5\ N$

Since $5.38N > 5N$

parcel does not move.

Leave blank

6. [*In this question the horizontal unit vectors* **i** *and* **j** *are due east and due north respectively.*]

A model boat A moves on a lake with constant velocity $(-\mathbf{i} + 6\mathbf{j})$ m s^{-1}. At time $t = 0$, A is at the point with position vector $(2\mathbf{i} - 10\mathbf{j})$ m. Find

(a) the speed of A,

(2)

(b) the direction in which A is moving, giving your answer as a bearing.

(3)

At time $t = 0$, a second boat B is at the point with position vector $(-26\mathbf{i} + 4\mathbf{j})$ m.

Given that the velocity of B is $(3\mathbf{i} + 4\mathbf{j})$ m s^{-1},

(c) show that A and B will collide at a point P and find the position vector of P.

(5)

Given instead that B has speed 8 m s^{-1} and moves in the direction of the vector $(3\mathbf{i} + 4\mathbf{j})$,

(d) find the distance of B from P when $t = 7$ s.

(6)

a) Speed $= \sqrt{(-1)^2 + 6^2} = 6.08 \text{ ms}^{-2}$

b)

$\alpha = \tan^{-1}\left(\frac{6}{1}\right) = 80.5°$

Moving on bearing $270° + 80.5°$

$= 350.5°$

c) $\underline{s}_A - \underline{s}_{OA} = \underline{v}_A t$ $\qquad$ $\underline{s}_B - \underline{s}_{OB} = \underline{v}_B t$

$\underline{s}_A - \begin{pmatrix} 2 \\ -10 \end{pmatrix} = \begin{pmatrix} -1 \\ 6 \end{pmatrix} t$ $\qquad$ $\underline{s}_B - \begin{pmatrix} -26 \\ 4 \end{pmatrix} = \begin{pmatrix} 3 \\ 4 \end{pmatrix} t$

Leave blank

Question 6 continued

$\underline{s}_A = \begin{pmatrix} 2-t \\ -10+6t \end{pmatrix}$ $\underline{s}_B = \begin{pmatrix} -26+3t \\ 4+4t \end{pmatrix}$

Solve $2 - t = -26 + 3t$

$28 = 4t$

$t = 7$

x - coords match when $t = 7$

$x_A = x_B = 2 - 7 = -5$

y - coords $y_A = -10 + 6(7) = 32$ $y_B = 4 + 4(7) = 32$

Collide when $t = 7$ at P

where $\overrightarrow{OP} = -5\underline{i} + 32\underline{j}$

d) Unit vector in direction $\begin{pmatrix} 3 \\ 4 \end{pmatrix}$ is $\frac{1}{5}\begin{pmatrix} 3 \\ 4 \end{pmatrix}$

$\therefore$ B has velocity $\frac{8}{5}\begin{pmatrix} 3 \\ 4 \end{pmatrix}$

$\underline{s}_B = \begin{pmatrix} -26 \\ 4 \end{pmatrix} + \frac{8}{5}\begin{pmatrix} 3 \\ 4 \end{pmatrix} t$

When $t = 7$ $\underline{s}_B = \begin{pmatrix} -26 \\ 4 \end{pmatrix} + \frac{8}{5}\begin{pmatrix} 3 \\ 4 \end{pmatrix} \times 7 = \begin{pmatrix} 7.6 \\ 48.8 \end{pmatrix}$

Distance from P $= \sqrt{(7.6 - -5)^2 + (48.8 - 32)^2} = 21$ m

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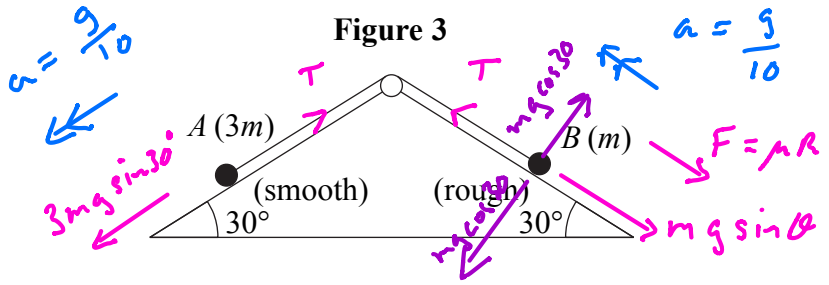
7.

Figure 3



A fixed wedge has two plane faces, each inclined at 30° to the horizontal. Two particles A and B, of mass $3m$ and m respectively, are attached to the ends of a light inextensible string. Each particle moves on one of the plane faces of the wedge. The string passes over a small smooth light pulley fixed at the top of the wedge. The face on which A moves is smooth. The face on which B moves is rough. The coefficient of friction between B and this face is μ. Particle A is held at rest with the string taut. The string lies in the same vertical plane as lines of greatest slope on each plane face of the wedge, as shown in Figure 3.

The particles are released from rest and start to move. Particle A moves downwards and B moves upwards. The accelerations of A and B each have magnitude $\frac{1}{10}g$.

(a) By considering the motion of A, find, in terms of m and g, the tension in the string.

(3)

(b) By considering the motion of B, find the value of μ.

(8)

(c) Find the resultant force exerted by the string on the pulley, giving its magnitude and direction.

(3)

a) N2L for A

$$3mg\sin 30^\circ - T = 3m \times \frac{g}{10}$$

$$\frac{3mg}{2} - \frac{3mg}{10} = T$$

$$T = \frac{6mg}{5}$$

b) N2L for B

$$T - mg\sin 30 - F = \frac{mg}{10}$$

$$T - \frac{mg}{2} - \mu mg\cos 30 = \frac{mg}{10}$$

Leave blank

Question 7 continued

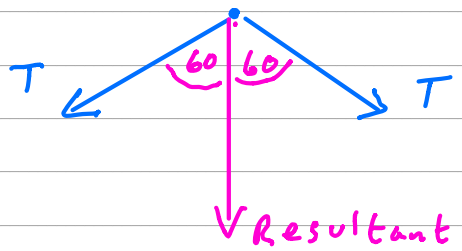
$$\frac{6mg}{5} - \frac{mg}{2} - \frac{mg}{10} = \mu mg\frac{\sqrt{3}}{2}$$

$$\frac{6}{5} - \frac{1}{2} - \frac{1}{10} = \frac{\sqrt{3}}{2}\mu$$

$$\frac{6}{10} \times \frac{2}{\sqrt{3}} = \mu$$

$$\mu = \frac{2\sqrt{3}}{5} = 0.693$$

c)



Resultant force on pulley vertically downwards

$= 2 \times T\cos 60$

$= 2 \times \frac{6mg}{5} \times \frac{1}{2}$

Magnitude $= \frac{6mg}{5}$ N

Q7

(Total 14 marks)

TOTAL FOR PAPER: 75 MARKS

END