Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						6	6	8	0	/	0	1	Signature	

Paper Reference(s)

6680/01

Edexcel GCE

Mechanics M4

Advanced/Advanced Subsidiary

Thursday 12 June 2008 – Morning

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	

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Materials required for examination
Mathematical Formulae (Green)

Items included with question papers
Nil

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initials and signature.
Check that you have the correct question paper.
Answer ALL the questions. Write your answers in the spaces provided in this question paper.
Whenever a numerical value of g is required, take $g = 9.8$ 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 24 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 should show sufficient working to make your methods clear to the Examiner.
Answers without working may not gain full credit.

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

A ship P is moving with velocity $(5\mathbf{i} - 4\mathbf{j})$ km h^{-1} and a ship Q is moving with velocity $(3\mathbf{i} + 7\mathbf{j})$ km h^{-1}. Find the direction that ship Q appears to be moving in, to an observer on ship P, giving your answer as a bearing.

(5)

Leave blank

Question 1 continued

Q1

(Total 5 marks)

Leave blank

2. Two small smooth spheres A and B have equal radii. The mass of A is $2m$ kg and the mass of B is m kg. The spheres are moving on a smooth horizontal plane and they collide. Immediately before the collision the velocity of A is $(2\mathbf{i} - 2\mathbf{j})$ m s^{-1} and the velocity of B is $(-3\mathbf{i} - \mathbf{j})$ m s^{-1}. Immediately after the collision the velocity of A is $(\mathbf{i} - 3\mathbf{j})$ m s^{-1}. Find the speed of B immediately after the collision.

(5)

4

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Question 2 continued

Q2

(Total 5 marks)

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3. At time $t = 0$, a particle of mass m is projected vertically downwards with speed U from a point above the ground. At time t the speed of the particle is v and the magnitude of the air resistance is modelled as being mkv, where k is a constant.

Given that $U < \frac{g}{2k}$, find, in terms of k, U and g, the time taken for the particle to double its speed.

(8)

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Question 3 continued

Q3

(Total 8 marks)

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4.

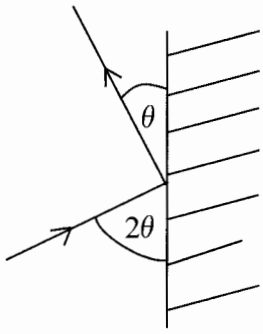

Figure 1

A small smooth ball B, moving on a horizontal plane, collides with a fixed vertical wall. Immediately before the collision the angle between the direction of motion of B and the wall is 2θ, where $0^\circ < \theta < 45^\circ$. Immediately after the collision the angle between the direction of motion of B and the wall is θ, as shown in Figure 1. Given that the coefficient of restitution between B and the wall is $\frac{3}{8}$, find the value of $\tan \theta$.

(8)

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Question 4 continued

Q4

(Total 8 marks)

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5. A light elastic spring has natural length l and modulus of elasticity mg. One end of the spring is fixed to a point O on a rough horizontal table. The other end is attached to a particle P of mass m which is at rest on the table with $OP = l$. At time $t = 0$ the particle is projected with speed $\sqrt{(gl)}$ along the table in the direction OP. At time t the displacement of P from its initial position is x and its speed is v. The motion of P is subject to air resistance of magnitude $2mv\omega$, where $\omega = \sqrt{\frac{g}{l}}$. The coefficient of friction between P and the table is 0.5.

(a) Show that, until P first comes to rest,

$$\frac{d^2x}{dt^2} + 2\omega\frac{dx}{dt} + \omega^2 x = -0.5g.$$

(6)

(b) Find x in terms of t, l and ω.

(6)

(c) Hence find, in terms of ω, the time taken for P to first come to instantaneous rest.

(3)

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Question 5 continued

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Question 5 continued

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Question 5 continued

(Total 15 marks)

Q5

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6.

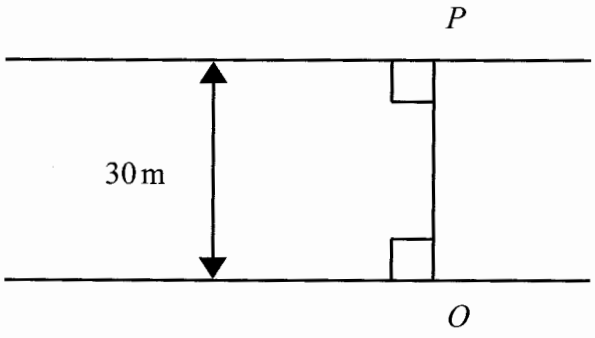

Figure 2

A river is 30 m wide and flows between two straight parallel banks. At each point of the river, the direction of flow is parallel to the banks. At time $t = 0$, a boat leaves a point O on one bank and moves in a straight line across the river to a point P on the opposite bank. Its path OP is perpendicular to both banks and $OP = 30$ m, as shown in Figure 2. The speed of flow of the river, r m s^{-1}, at a point on OP which is at a distance x m from O, is modelled as

$$r = \frac{1}{10}x, \quad 0 \leqslant x \leqslant 30.$$

The speed of the boat relative to the water is constant at 5 m s^{-1}. At time t seconds the boat is at a distance x m from O and is moving with speed v m s^{-1} in the direction OP.

(a) Show that

$$100v^2 = 2500 - x^2.$$

(3)

(b) Hence show that

$$\frac{d^2x}{dt^2} + \frac{x}{100} = 0.$$

(4)

(c) Find the total time taken for the boat to cross the river from O to P.

(9)

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Question 6 continued

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Question 6 continued

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Question 6 continued

Q6

(Total 16 marks)

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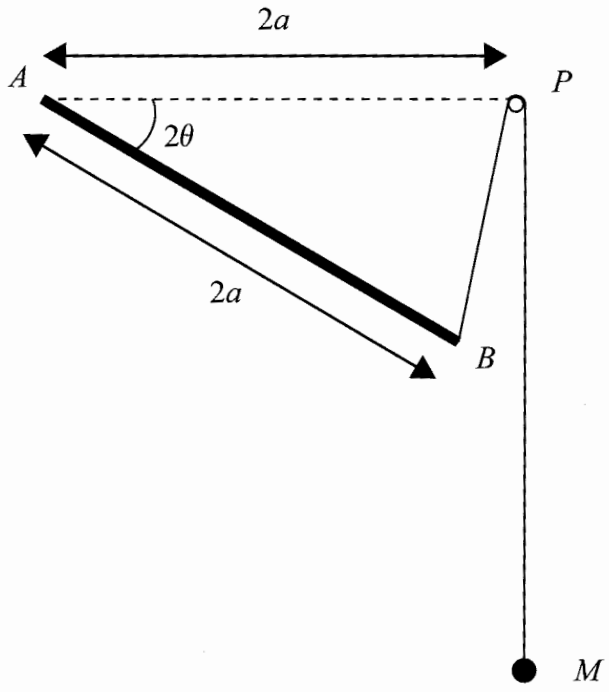

Figure 3

A uniform rod AB, of length $2a$ and mass kM where k is a constant, is free to rotate in a vertical plane about the fixed point A. One end of a light inextensible string of length $6a$ is attached to the end B of the rod and passes over a small smooth pulley which is fixed at the point P. The line AP is horizontal and of length $2a$. The other end of the string is attached to a particle of mass M which hangs vertically below the point P, as shown in Figure 3. The angle PAB is 2θ, where $0^\circ \leqslant \theta \leqslant 180^\circ$.

(a) Show that the potential energy of the system is

$$Mga(4\sin\theta - k\sin 2\theta) + \text{constant}.$$

(5)

The system has a position of equilibrium when $\cos\theta = \frac{3}{4}$.

(b) Find the value of k.

(5)

(c) Hence find the value of $\cos\theta$ at the other position of equilibrium.

(3)

(d) Determine the stability of each of the two positions of equilibrium.

(5)

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Question 7 continued

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Question 7 continued

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Question 7 continued

Q7

(Total 18 marks)

TOTAL FOR PAPER: 75 MARKS

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