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

Wednesday 22 June 2011 – 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	

Materials required for examination	**Items included with question papers**
Mathematical Formulae (Pink)	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 or symbolic differentation/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.
You must write your answer to each question in the space following the question.
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.

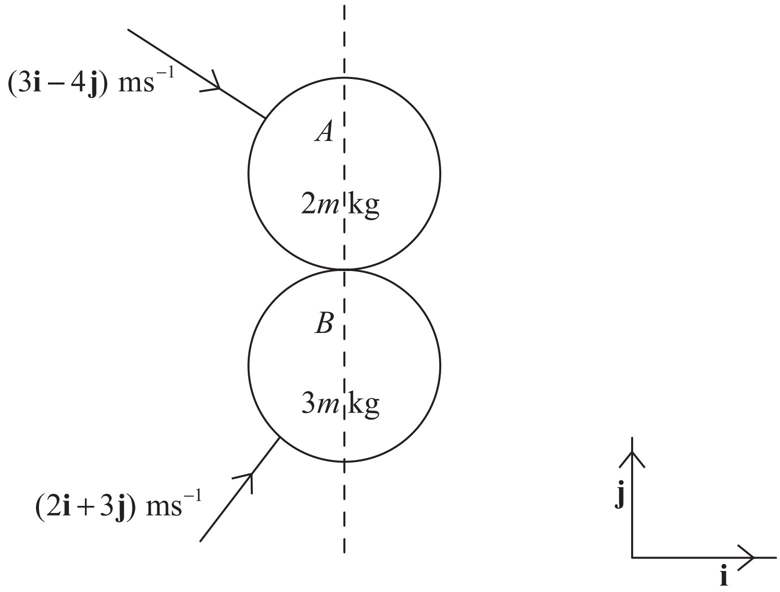

Figure 1

Two smooth uniform spheres A and B have masses $2m$ kg and $3m$ kg respectively and equal radii. The spheres are moving on a smooth horizontal surface. Initially, sphere A has velocity $(3\mathbf{i} - 4\mathbf{j})$ m s^{-1} and sphere B has velocity $(2\mathbf{i} - 3\mathbf{j})$ m s^{-1}. When the spheres collide, the line joining their centres is parallel to $\mathbf{j}$, as shown in Figure 1. The coefficient of restitution between the spheres is $\frac{3}{7}$. Find, in terms of m, the total kinetic energy lost in the collision.

(10)

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Question 1 continued

(Total 10 marks)

Q1

Leave blank

2.

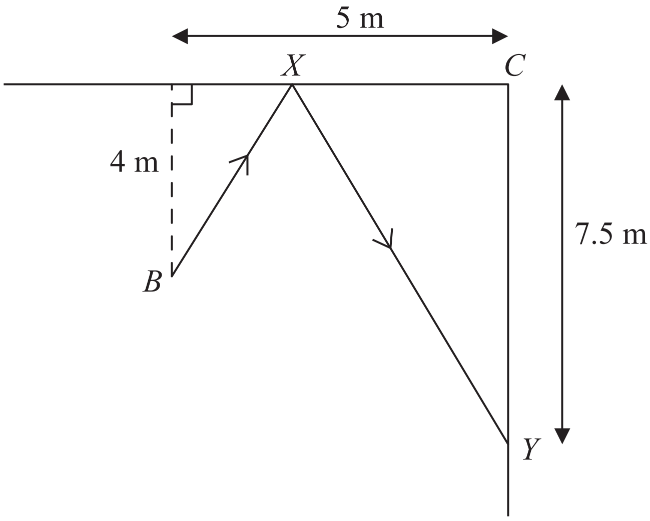

Figure 2

Figure 2 represents part of the smooth rectangular floor of a sports hall. A ball is at B, 4 m from one wall of the hall and 5 m from an adjacent wall. These two walls are smooth and meet at the corner C. The ball is kicked so that it travels along the floor, bounces off the first wall at the point X and hits the second wall at the point Y. The point Y is 7.5 m from the corner C.

The coefficient of restitution between the ball and the first wall is $\frac{3}{4}$.

Modelling the ball as a particle, find the distance CX.

(9)

Leave blank

Question 2 continued

Q2

(Total 9 marks)

P 3 5 4 1 5 A 0 5 2 4

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

A coastguard patrol boat C is moving with constant velocity $(8\mathbf{i} + u\mathbf{j})$ km h^{-1}. Another ship S is moving with constant velocity $(12\mathbf{i} + 16\mathbf{j})$ km h^{-1}.

(a) Find, in terms of u, the velocity of C relative to S.

(2)

At noon, S is 10 km due west of C.
If C is to intercept S,

(b) (i) find the value of u.

(ii) Using this value of u, find the time at which C would intercept S.

(4)

If instead, at noon, C is moving with velocity $(8\mathbf{i} + 8\mathbf{j})$ km h^{-1} and continues at this constant velocity,

(c) find the distance of closest approach of C to S.

(5)

Leave blank

Question 3 continued

P 3 5 4 1 5 A 0 7 2 4

Leave blank

4. A hiker walking due east at a steady speed of 5 km h^{-1} notices that the wind appears to come from a direction with bearing 050. At the same time, another hiker moving on a bearing of 320, and also walking at 5 km h^{-1}, notices that the wind appears to come from due north.

Find

(a) the direction from which the wind is blowing,

(3)

(b) the wind speed.

(4)

Leave blank

5. A particle Q of mass 6 kg is moving along the x-axis. At time t seconds the displacement of Q from the origin O is x metres and the speed of Q is v m s^{-1}. The particle moves under the action of a retarding force of magnitude $(a + bv^2)$ N, where a and b are positive constants. At time $t = 0$, Q is at O and moving with speed U m s^{-1} in the positive x-direction. The particle Q comes to instantaneous rest at the point X.

(a) Show that the distance OX is

$$\frac{3}{b}\ln\left(1+\frac{bU^2}{a}\right) \text{ m}$$

(6)

Given that $a = 12$ and $b = 3$,

(b) find, in terms of U, the time taken to move from O to X.

(5)

Leave blank

Question 5 continued

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6. A particle P of mass 4 kg moves along a horizontal straight line under the action of a force directed towards a fixed point O on the line. At time t seconds, P is x metres from O and the force towards O has magnitude $9x$ newtons. The particle P is also subject to air resistance, which has magnitude $12v$ newtons when P is moving with speed v m s^{-1}.

(a) Show that the equation of motion of P is

$$4\frac{d^2x}{dt^2}+12\frac{dx}{dt}+9x=0$$

(4)

It is given that the solution of this differential equation is of the form

$$x = e^{-\lambda t}(At + B)$$

When $t = 0$ the particle is released from rest at the point R, where $OR = 4$ m.

Find,

(b) the values of the constants λ, A and B,

(4)

(c) the greatest speed of P in the subsequent motion.

(5)

Leave blank

Question 6 continued

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7.

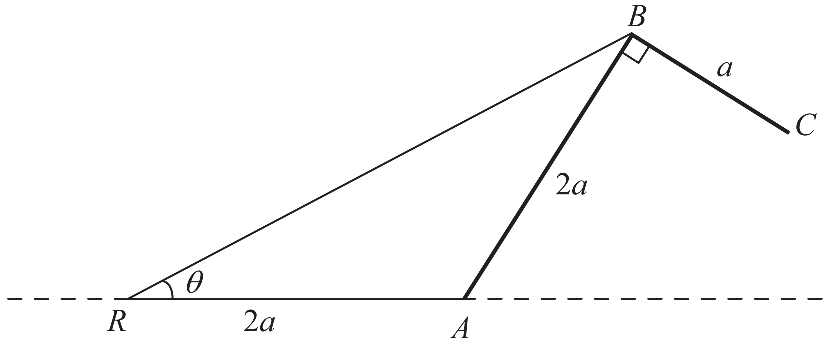

Figure 3

Figure 3 shows a framework ABC, consisting of two uniform rods rigidly joined together at B so that $\angle ABC = 90°$. The rod AB has length $2a$ and mass $4m$, and the rod BC has length a and mass $2m$. The framework is smoothly hinged at A to a fixed point, so that the framework can rotate in a fixed vertical plane. One end of a light elastic string, of natural length $2a$ and modulus of elasticity $3mg$, is attached to A. The string passes through a small smooth ring R fixed at a distance $2a$ from A, on the same horizontal level as A and in the same vertical plane as the framework. The other end of the string is attached to B. The angle ARB is θ, where $0 < \theta < \frac{\pi}{2}$.

(a) Show that the potential energy V of the system is given by

$$V = 8amg \sin 2\theta + 5amg \cos 2\theta + \text{constant}$$

(7)

(b) Find the value of θ for which the system is in equilibrium.

(4)

(c) Determine the stability of this position of equilibrium.

(3)

Leave blank

Question 7 continued