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

Friday 5 June 2015 – 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} and give your answer to either two significant figures or three significant figures.
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 28 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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PEARSON

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1. Particles P and Q move in a plane with constant velocities. At time $t = 0$ the position vectors of P and Q, relative to a fixed point O in the plane, are $(16\mathbf{i} - 12\mathbf{j})$ m and $(-5\mathbf{i} + 4\mathbf{j})$ m respectively. The velocity of P is $(\mathbf{i} + 2\mathbf{j})\,\text{m s}^{-1}$ and the velocity of Q is $(2\mathbf{i} + \mathbf{j})\,\text{m s}^{-1}$

Find the shortest distance between P and Q in the subsequent motion.

(7)

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Question 1 continued

Q1

(Total 7 marks)

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2. When a woman walks due North at a constant speed of 4 km h^{-1}, the wind appears to be blowing from due East. When she runs due South at a constant speed of 8 km h^{-1}, the speed of the wind appears to be 20 km h^{-1}.

Assuming that the velocity of the wind relative to the earth is constant, find

(i) the speed of the wind,

(ii) the direction from which the wind is blowing.

(6)

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Question 2 continued

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Question 2 continued

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Question 2 continued

Q2

(Total 6 marks)

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3.

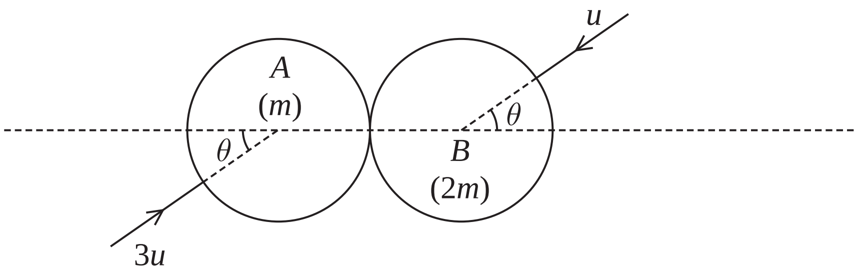

Figure 1

Two smooth uniform spheres A and B with equal radii have masses m and $2m$ respectively. The spheres are moving in opposite directions on a smooth horizontal surface and collide obliquely. Immediately before the collision, A has speed $3u$ with its direction of motion at an angle θ to the line of centres, and B has speed u with its direction of motion at an angle θ to the line of centres, as shown in Figure 1. The coefficient of restitution between the spheres is $\frac{1}{8}$

Immediately after the collision, the speed of A is twice the speed of B.

Find the size of the angle θ.

(12)

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Question 3 continued

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Question 3 continued

Leave blank

Question 3 continued

Q3

(Total 12 marks)

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4. A car of mass 900 kg is moving along a straight horizontal road with the engine of the car working at a constant rate of 22.5 kW. At time t seconds, the speed of the car is v m s^{-1} $(0 < v < 30)$ and the total resistance to the motion of the car has magnitude $25v$ newtons.

(a) Show that when the speed of the car is v m s^{-1}, the acceleration of the car is

$$\frac{900 - v^2}{36v} \text{ m s}^{-2}$$

(3)

The time taken for the car to accelerate from 10 m s^{-1} to 20 m s^{-1} is T seconds.

(b) Show that

$$T = 18 \ln \frac{8}{5}$$

(5)

(c) Find the distance travelled by the car as it accelerates from 10 m s^{-1} to 20 m s^{-1}

(6)

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Question 4 continued

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Question 4 continued

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Question 4 continued

Q4

(Total 14 marks)

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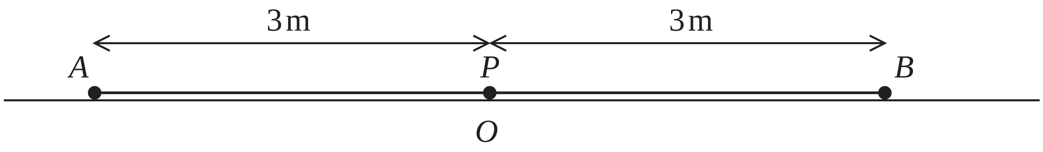

Figure 2

A particle P of mass 1.5 kg is attached to the midpoint of a light elastic spring AB, of natural length 2 m and modulus of elasticity 12 N. The end A of the spring is attached to a fixed point on a smooth horizontal floor. The end B is held at a point on the floor where $AB = 6$ m.

At time $t = 0$, P is at rest on the floor at the point O, where $AO = 3$ m, as shown in Figure 2. The end B is now moved along the floor in such a way that AOB remains a straight line and at time t seconds, $t \geqslant 0$,

$$AB = \left(6 + \frac{1}{4}\sin 2t\right)\text{m}$$

At time t seconds, $AP = (3 + x)$ m.

(a) Show that, for $t \geqslant 0$,

$$\frac{d^2x}{dt^2} + 16x = 2\sin 2t$$

(5)

The general solution of this differential equation is

$$x = C\cos 4t + D\sin 4t + \frac{1}{6}\sin 2t$$

where C and D are constants.

(b) Find the time at which P first comes to instantaneous rest.

(5)

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Question 5 continued

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Question 5 continued

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Question 5 continued

Q5

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6.

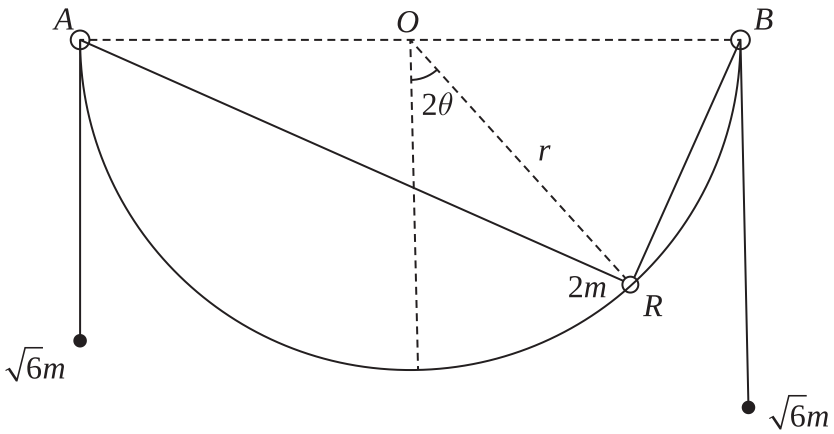

Figure 3

A smooth wire, with ends A and B, is in the shape of a semicircle of radius r. The line AB is horizontal and the midpoint of AB is O. The wire is fixed in a vertical plane. A small ring R of mass $2m$ is threaded on the wire and is attached to two light inextensible strings. One string passes through a small smooth ring fixed at A and is attached to a particle of mass $\sqrt{6}m$. The other string passes through a small smooth ring fixed at B and is attached to a second particle of mass $\sqrt{6}m$. The particles hang freely under gravity, as shown in Figure 3. The angle between the radius OR and the downward vertical is 2θ, where $-\frac{\pi}{4} < \theta < \frac{\pi}{4}$

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

$$2mgr\left(2\sqrt{3}\cos\theta - \cos 2\theta\right) + \text{constant}$$

(6)

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

(4)

(c) Determine the stability of the position of equilibrium for which $\theta > 0$

(3)

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Question 6 continued

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Question 6 continued

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Question 6 continued

Q6

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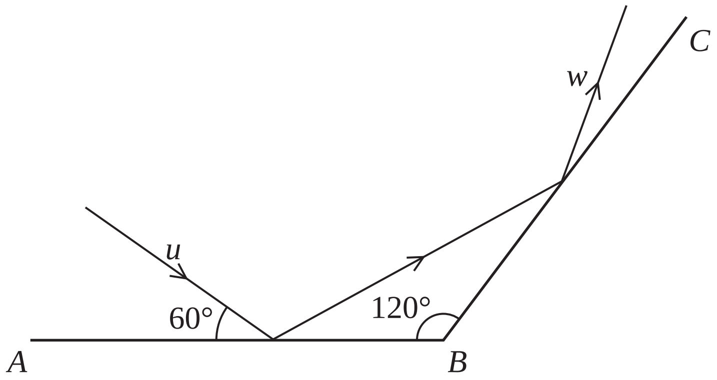

Figure 4

Figure 4 represents the plan view of part of a smooth horizontal floor, where *AB* and *BC* are smooth vertical walls. The angle between *AB* and *BC* is 120°. A ball is projected along the floor towards *AB* with speed u m s^{-1} on a path at an angle of 60° to *AB*. The ball hits *AB* and then hits *BC*. The ball is modelled as a particle. The coefficient of restitution between the ball and each wall is $\frac{1}{2}$

(a) Show that the speed of the ball immediately after it has hit *AB* is $\frac{\sqrt{7}}{4}u$.

(6)

The speed of the ball immediately after it has hit *BC* is w m s^{-1}

(b) Find w in terms of u.

(7)

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Question 7 continued

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Question 7 continued

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Question 7 continued

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Question 7 continued

Q7

(Total 13 marks)

TOTAL FOR PAPER: 75 MARKS

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