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

Paper Reference(s)

6680/01R

Edexcel GCE

Mechanics M4

Advanced/Advanced Subsidiary

Tuesday 18 June 2013 – 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
Mathematical Formulae (Pink)

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

Boat A is moving with velocity $(3\mathbf{i} + 4\mathbf{j})$ km h^{-1} and boat B is moving with velocity $(6\mathbf{i} - 5\mathbf{j})$ km h^{-1}. Find

(a) the magnitude of the velocity of A relative to B,

(3)

(b) the direction of the velocity of A relative to B, giving your answer as a bearing.

(2)

Leave blank

2.

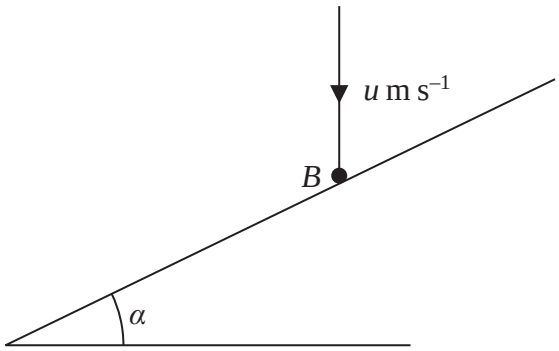

Figure 1

A smooth fixed plane is inclined at an angle α to the horizontal. A smooth ball B falls vertically and hits the plane. Immediately before the impact the speed of B is u m s^{-1}, as shown in Figure 1. Immediately after the impact the direction of motion of B is horizontal. The coefficient of restitution between B and the plane is $\frac{1}{3}$.

Find the size of angle α.

(6)

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Question 2 continued

Q2

(Total 6 marks)

Leave blank

3. A smooth uniform sphere A, of mass $5m$ and radius r, is at rest on a smooth horizontal plane. A second smooth uniform sphere B, of mass $3m$ and radius r, is moving in a straight line on the plane with speed $u\,\text{m s}^{-1}$ and strikes A. Immediately before the impact the direction of motion of B makes an angle of 60° with the line of centres of the spheres. The direction of motion of B is turned through an angle of 30° by the impact.

Find

(a) the speed of B immediately after the impact,

(3)

(b) the coefficient of restitution between the spheres.

(6)

Leave blank

Question 3 continued

Leave blank

4. At 10 a.m. two walkers *A* and *B* are 4 km apart with *A* due north of *B*. Walker *A* is moving due east at a constant speed of 6 km h^{-1}. Walker *B* is moving with constant speed 5 km h^{-1} and walks in the straight line which allows him to pass as close as possible to *A*.

Find

(a) the direction of motion of *B*, giving your answer as a bearing,

(4)

(b) the least distance between *A* and *B*,

(2)

(c) the time when the distance between *A* and *B* is least.

(4)

Leave blank

Question 4 continued

Leave blank

5. A van of mass 1200 kg travels along a straight horizontal road against a resistance to motion which is proportional to the speed of the van. The engine of the van is working at a constant rate of 40 kW. The van starts from rest at time $t = 0$. At time t seconds, the speed of the van is v m s^{-1}. When the speed of the van is 40 m s^{-1}, the acceleration of the van is 0.3 m s^{-2}.

(a) Show that

$$75v\frac{dv}{dt} = 2500 - v^2$$

(6)

(b) Find v in terms of t.

(6)

Leave blank

Question 5 continued

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6.

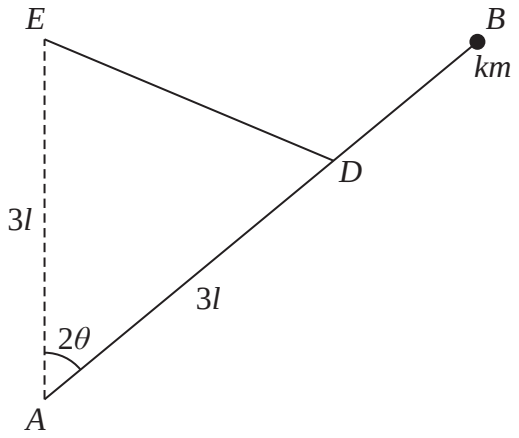

Figure 2

A uniform rod AB has mass $4m$ and length $4l$. The rod can turn freely in a vertical plane about a fixed smooth horizontal axis through A. A particle of mass km, where $k < 7$, is attached to the rod at B. One end of a light elastic string, of natural length l and modulus of elasticity $4mg$, is attached to the point D of the rod, where $AD = 3l$. The other end of the string is attached to a fixed point E which is vertically above A, where $AE = 3l$, as shown in Figure 2. The angle between the rod and the upward vertical is 2θ, where $\arcsin\left(\frac{1}{6}\right) < \theta \leqslant \frac{\pi}{2}$.

(a) Show that, while the string is stretched, the potential energy of the system is

$$8mgl\{(7-k)\sin^2\theta - 3\sin\theta\} + \text{constant}$$

(6)

There is a position of equilibrium with $\theta \leqslant \frac{\pi}{6}$.

(b) Show that $k \leqslant 4$

(5)

Given that $k = 4$,

(c) show that this position of equilibrium is stable.

(5)

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Question 6 continued

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7. A particle P of mass 0.5 kg is attached to the end A of a light elastic spring AB, of natural length 0.6 m and modulus of elasticity 2.7 N. At time $t = 0$ the end B of the spring is held at rest and P hangs at rest at the point C which is vertically below B. The end B is then moved along the line of the spring so that, at time t seconds, the downwards displacement of B from its initial position is $4\sin 2t$ metres. At time t seconds, the extension of the spring is x metres and the displacement of P below C is y metres.

(a) Show that

$$y + \frac{49}{45} = x + 4\sin 2t$$

(3)

(b) Hence show that

$$\frac{\mathrm{d}^2 y}{\mathrm{d}t^2} + 9y = 36\sin 2t$$

(5)

Given that $y = \frac{36}{5}\sin 2t$ is a particular integral of this differential equation,

(c) find y in terms of t,

(5)

(d) find the speed of P when $t = \frac{1}{3}\pi$.

(4)

Leave blank

Question 7 continued