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

Paper Reference(s)

6681/01

Edexcel GCE

Mechanics M5

Advanced/Advanced Subsidiary

Monday 24 June 2013 – 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 (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 differentiation/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. Solve the differential equation

$$\frac{d\mathbf{r}}{dt} - 2\mathbf{r} = \mathbf{0}$$

given that when $t = 0$, $\mathbf{r}.\mathbf{j} = 0$ and $\mathbf{r} \times \mathbf{j} = \mathbf{i} + \mathbf{k}$.

(7)

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2. A uniform square lamina S has side $2a$. The radius of gyration of S about an axis through a vertex, perpendicular to S, is k.

(a) Show that $k^2 = \dfrac{8a^2}{3}$.

(4)

The lamina S is free to rotate in a vertical plane about a fixed smooth horizontal axis which is perpendicular to S and passes through a vertex.

(b) By writing down an equation of rotational motion for S, find the period of small oscillations of S about its position of stable equilibrium.

(5)

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3. A raindrop falls vertically under gravity through a stationary cloud. At time $t = 0$, the raindrop is at rest and has mass m_0. As the raindrop falls, water condenses onto it from the cloud so that the mass of the raindrop increases at a constant rate c. At time t, the mass of the raindrop is m and the speed of the raindrop is v. The resistance to the motion of the raindrop has magnitude mkv, where k is a constant. Show that

$$\frac{\mathrm{d}v}{\mathrm{d}t} + v\left(k + \frac{c}{m_0 + ct}\right) = g$$

(7)

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4. Three forces $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ act on a rigid body. The forces $\mathbf{F}_1$ and $\mathbf{F}_2$ act through the points with position vectors $\mathbf{r}_1$ and $\mathbf{r}_2$ respectively.

$\mathbf{r}_1 = (-2\mathbf{i} + 3\mathbf{j})$ m, $\quad \mathbf{F}_1 = (3\mathbf{i} - 2\mathbf{j} + \mathbf{k})$ N

$\mathbf{r}_2 = (3\mathbf{i} + 2\mathbf{k})$ m, $\quad \mathbf{F}_2 = (-2\mathbf{i} + \mathbf{j} - \mathbf{k})$ N

Given that the system $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ is in equilibrium,

(a) find $\mathbf{F}_3$,

(2)

(b) find a vector equation of the line of action of $\mathbf{F}_3$, giving your answer in the form $\mathbf{r} = \mathbf{a} + t\mathbf{b}$.

(5)

The force $\mathbf{F}_3$ is replaced by a force $\mathbf{F}_4$ acting through the point with position vector $(\mathbf{i} - 2\mathbf{j} + 3\mathbf{k})$ m. The system $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_4$ is equivalent to a single force $(3\mathbf{i} + \mathbf{j} + \mathbf{k})$ N acting through the point with position vector $(\mathbf{i} + \mathbf{j} + \mathbf{k})$ m together with a couple.

(c) Find the magnitude of this couple.

(8)

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Question 4 continued

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5.

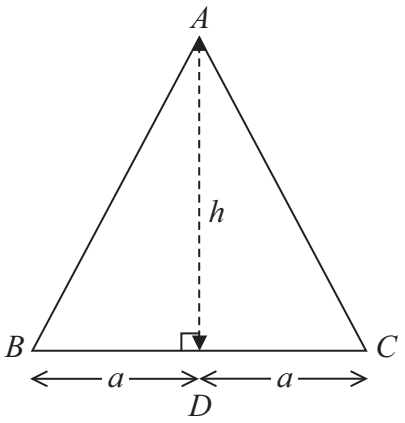

Figure 1

A uniform triangular lamina ABC, of mass M, has $AB = AC$ and $BC = 2a$. The mid-point of BC is D and $AD = h$, as shown in Figure 1.

Show, using integration, that the moment of inertia of the lamina about an axis through A, perpendicular to the plane of the lamina, is

$$\frac{M}{6}(a^2 + 3h^2)$$

[*You may assume without proof that the moment of inertia of a uniform rod, of length 2l and mass m, about an axis through its midpoint and perpendicular to the rod, is* $\frac{1}{3}ml^2$.]

(10)

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Question 5 continued

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6.

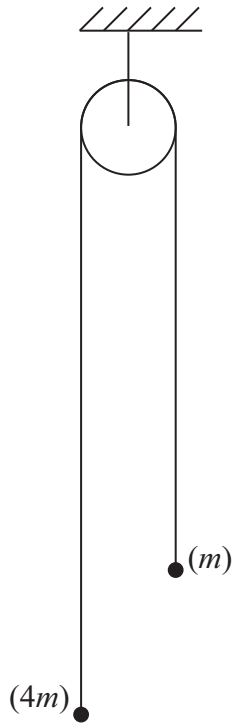

Figure 2

A light inextensible string has a particle of mass m attached to one end and a particle of mass $4m$ attached to the other end. The string passes over a rough pulley which is modelled as a uniform circular disc of radius a and mass $2m$, as shown in Figure 2.

The pulley can rotate in a vertical plane about a fixed horizontal axis which passes through the centre of the pulley and is perpendicular to the plane of the pulley. As the pulley rotates, a frictional couple of constant magnitude $2mga$ acts on it.

The system is held with the string vertical and taut on each side of the pulley and released from rest. Given that the string does not slip on the pulley, find the initial angular acceleration of the pulley.

(10)

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Question 6 continued

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7. A uniform circular disc, of radius r and mass m, is free to rotate in a vertical plane about a fixed smooth horizontal axis. This axis is perpendicular to the plane of the disc and passes through a point A on the circumference of the disc. The disc is held with AB horizontal, where AB is a diameter of the disc, and released from rest.

(a) Find the magnitude of

(i) the horizontal component,

(ii) the vertical component

of the force exerted on the disc by the axis immediately after the disc is released.

(11)

When AB is vertical the disc is instantaneously brought to rest by a horizontal impulse which acts in the plane of the disc and is applied to the disc at B.

(b) Find the magnitude of the impulse.

(6)

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Question 7 continued