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

Wednesday 18 June 2014 – 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	
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} and give your answer to 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 6 questions in this question paper. The total mark for this paper is 75.
There are 20 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. A small bead is threaded on a smooth, straight horizontal wire which passes through the point $A(-3, 1)$ and the point $B(2, 5)$ in the x-y plane. The bead moves under the action of a horizontal force **F** of magnitude 8.5 N whose line of action is parallel to the line with equation $15x - 8y + 4 = 0$. The unit on both the x and y axes has length one metre. Find the work done by **F** as it moves the bead from A to B.

(8)

Leave blank

Question 1 continued

Q1

(Total 8 marks)

Leave blank

2. A particle P moves in a plane so that its position vector, $\mathbf{r}$ metres at time t seconds, satisfies the differential equation

$$\frac{d\mathbf{r}}{dt} + \mathbf{r} = t\mathbf{i} + e^{-t}\mathbf{j}$$

When $t = 0$ the particle is at the point with position vector $(\mathbf{i} + \mathbf{j})$ m.

Find $\mathbf{r}$ in terms of t.

(9)

Leave blank

Question 2 continued

Q2

(Total 9 marks)

Leave blank

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

$\mathbf{F}_1 = (2\mathbf{i} + 3\mathbf{j} - \mathbf{k})$ N and $\mathbf{r}_1 = (\mathbf{i} + \mathbf{j} - 2\mathbf{k})$ m,
$\mathbf{F}_2 = (\mathbf{i} - 4\mathbf{j} - 2\mathbf{k})$ N and $\mathbf{r}_2 = (3\mathbf{i} - \mathbf{j} - \mathbf{k})$ m,
$\mathbf{F}_3 = (-3\mathbf{i} + \mathbf{j} + 3\mathbf{k})$ N and $\mathbf{r}_3 = (\mathbf{i} - 2\mathbf{j} + \mathbf{k})$ m.

Show that the system is equivalent to a couple and find the magnitude of the vector moment of this couple.

(9)

Leave blank

Question 3 continued

Q3

(Total 9 marks)

Leave blank

4. A spacecraft is travelling in a straight line in deep space where all external forces can be assumed to be negligible. The spacecraft decelerates by ejecting fuel at a constant speed k relative to the spacecraft, in the direction of motion of the spacecraft. At time t, the spacecraft has speed v and mass m.

(a) Show, from first principles, that while the spacecraft is ejecting fuel,

$$\frac{\mathrm{d}v}{\mathrm{d}m} - \frac{k}{m} = 0$$

(5)

At time $t = 0$, the spacecraft has speed U and mass M.

(b) Find the mass of the spacecraft when it comes to rest.

(6)

Given that $m = Me^{-\alpha t^2}$, where α is a positive constant, and that the spacecraft comes to rest at time $t = T$,

(c) find, in terms of U and T only, the distance travelled by the spacecraft in decelerating from speed U to rest.

(6)

Leave blank

Question 4 continued

Leave blank

Question 4 continued

Leave blank

Question 4 continued

Q4

(Total 17 marks)

Leave blank

5. A uniform rod AB, of mass m and length $2a$, is free to rotate in a vertical plane about a fixed smooth horizontal axis L. The axis L is perpendicular to the rod and passes through the point P of the rod, where $AP = \frac{2}{3}a$.

(a) Find the moment of inertia of the rod about L.

(3)

The rod is held at rest with B vertically above P and is slightly displaced.

(b) Find the angular speed of the rod when PB makes an angle θ with the upward vertical.

(4)

(c) Find the magnitude of the angular acceleration of the rod when PB makes an angle θ with the upward vertical.

(3)

(d) Find, in terms of g and a only, the angular speed of the rod when the force acting on the rod at P is perpendicular to the rod.

(5)

Leave blank

Question 5 continued

Leave blank

Question 5 continued

Leave blank

Question 5 continued

Q5

(Total 15 marks)

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6. (a) Prove, using integration, that the moment of inertia of a uniform circular disc, of mass m and radius a, about an axis through the centre of the disc and perpendicular to the plane of the disc is $\frac{1}{2}ma^2$.

(5)

[*You may assume without proof that the moment of inertia of a uniform hoop of mass m and radius r about an axis through its centre and perpendicular to its plane is* mr^2.]

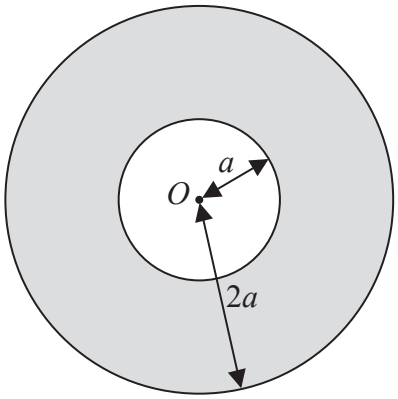

Figure 1

A uniform plane shape S of mass M is formed by removing a uniform circular disc with centre O and radius a from a uniform circular disc with centre O and radius $2a$, as shown in Figure 1. The shape S is free to rotate about a fixed smooth axis L, which passes through O and lies in the plane of the shape.

(b) Show that the moment of inertia of S about L is $\frac{5}{4}Ma^2$.

(4)

The shape S is at rest in a horizontal plane and is free to rotate about the axis L. A particle of mass M falls vertically and strikes S at the point A, where $OA = \frac{3}{2}a$ and OA is perpendicular to L. The particle adheres to S at A. Immediately before the particle strikes S the speed of the particle is u.

(c) Find, in terms of M and u, the loss in kinetic energy due to the impact.

(8)

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Question 6 continued

Leave blank

Question 6 continued

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Question 6 continued

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Question 6 continued

Q6

(Total 17 marks)

TOTAL FOR PAPER: 75 MARKS

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