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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

Friday 12 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
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}, 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. A particle P moves from the point A, with position vector $(2\mathbf{i} + 4\mathbf{j} + a\mathbf{k})$ m, where a is a positive constant, to the point B, with position vector $(-\mathbf{i} + a\mathbf{j} - \mathbf{k})$ m, under the action of a constant force $\mathbf{F} = (2\mathbf{i} + a\mathbf{j} - 3\mathbf{k})$ N. The work done by $\mathbf{F}$, as it moves the particle P from A to B, is 3 J. Find the value of a.

(6)

Leave blank

Question 1 continued

Q1

(Total 6 marks)

Leave blank

2. A particle P moves so that its position vector, $\mathbf{r}$ metres, at time t seconds, where $0 \leqslant t < \frac{\pi}{2}$, satisfies the differential equation

$$\frac{\mathrm{d}\mathbf{r}}{\mathrm{d}t} - (\tan t)\mathbf{r} = (\sin t)\mathbf{i}$$

When $t = 0$, $\mathbf{r} = -\frac{1}{2}\mathbf{i}$.

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

(8)

Leave blank

Question 2 continued

Leave blank

Question 2 continued

Leave blank

Question 2 continued

Q2

(Total 8 marks)

Leave blank

3. A rigid body is in equilibrium under the action of three forces $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$

$\mathbf{F}_1$ and $\mathbf{F}_2$ act at the points with position vectors $\mathbf{r}_1$ and $\mathbf{r}_2$ respectively, where

$\mathbf{F}_1 = (2\mathbf{j} + \mathbf{k})$ N $\quad \mathbf{r}_1 = (\mathbf{i} + 2\mathbf{j} + 2\mathbf{k})$ m
$\mathbf{F}_2 = (-2\mathbf{i} - \mathbf{j})$ N $\quad \mathbf{r}_2 = (-\mathbf{i} - \mathbf{j} + \mathbf{k})$ m

(a) Find the magnitude of $\mathbf{F}_3$

(4)

(b) Find a vector equation of the line of action of $\mathbf{F}_3$, giving your answer in the form $\mathbf{r} = \mathbf{a} + t\mathbf{b}$, where $\mathbf{a}$ and $\mathbf{b}$ are constant vectors and t is a scalar parameter.

(8)

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Question 3 continued

Leave blank

Question 3 continued

Leave blank

Question 3 continued

(Total 12 marks)

Q3

Leave blank

4. A particle P, whose initial mass is m_0, is projected vertically upwards from the ground at time $t = 0$ with speed $\frac{g}{k}$, where k is a constant. As the particle moves upwards it gains mass by picking up small droplets of moisture from the atmosphere. The droplets are at rest before they are picked up. At time t the speed of P is v and its mass has increased to $m_0 e^{kt}$. Assuming that, during the motion, the acceleration due to gravity is constant,

(a) show that, while P is moving upwards,

$$kv + \frac{dv}{dt} = -g$$

(6)

(b) find, in terms of m_0, the mass of P when it reaches its greatest height above the ground.

(6)

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Question 4 continued

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Question 4 continued

Leave blank

Question 4 continued

Q4

(Total 12 marks)

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5. A uniform circular disc, of mass m and radius a, is free to rotate about a fixed smooth horizontal axis L. The axis L is a tangent to the disc at the point A. The centre O of the disc moves in a vertical plane that is perpendicular to L.

The disc is held at rest with its plane horizontal and released.

(a) Find the angular acceleration of the disc when it has turned through an angle of $\frac{\pi}{3}$

(5)

(b) Find the magnitude of the component, in a direction perpendicular to the disc, of the force of the axis L acting on the disc at A, when the disc has turned through an angle of $\frac{\pi}{3}$

(4)

Leave blank

Question 5 continued

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Question 5 continued

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Question 5 continued

Q5

(Total 9 marks)

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6. A pendulum is modelled as a uniform rod AB, of mass $3m$ and length $2a$, which has a particle of mass $2m$ attached at B. The pendulum is free to rotate in a vertical plane about a fixed smooth horizontal axis L which passes through A. The vertical plane is perpendicular to the axis L.

(a) Find the period of small oscillations of the pendulum about its position of stable equilibrium.

(8)

The pendulum is hanging at rest in a vertical position, with B below A, when it is given a horizontal impulse of magnitude J. The impulse acts at B in a vertical plane which is perpendicular to the axis L.

Given that the pendulum turns through an angle of 60° before first coming to instantaneous rest,

(b) find J.

(8)

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Question 6 continued

Leave blank

Question 6 continued

Leave blank

Question 6 continued

Q6

(Total 16 marks)

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7. (a) Find, using integration, the moment of inertia of a uniform solid hemisphere, of mass m and radius a, about a diameter of its plane face.

[*You may assume, without proof, that the moment of inertia of a uniform circular disc, of mass m and radius r, about a diameter is* $\frac{1}{4}mr^2$.]

(10)

(b) Hence find the moment of inertia of a uniform solid sphere, of mass M and radius a, about a diameter.

(2)

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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 12 marks)

TOTAL FOR PAPER: 75 MARKS

END