Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						6	6	7	8	/	0	1	Signature	

Paper Reference(s)

6678/01

Edexcel GCE

Mechanics M2

Advanced/Advanced Subsidiary

Tuesday 6 June 2006 – 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	
8	
Total	

Materials required for examination
Mathematical Formulae (Green)

Items included with question papers
Nil

Candidates may use any calculator EXCEPT those with the facility for symbolic algebra, differentiation and/or integration. Thus candidates may NOT use calculators such as the Texas Instruments TI 89, TI 92, Casio CFX 9970G, Hewlett Packard HP 48G.

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature.
Check that you have the correct question paper.
You must write your answer to each question in the space following the question.
If you need more space to complete your answers to any question, use additional sheets.
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 8 questions in this question paper. The total mark for this question 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 must show sufficient working to make your methods clear to the Examiner. Answers without working may gain no credit.

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1. A particle P moves on the x-axis. At time t seconds, its acceleration is $(5 - 2t)\,\text{m s}^{-2}$, measured in the direction of x increasing. When $t = 0$, its velocity is $6\,\text{m s}^{-1}$ measured in the direction of x increasing. Find the time when P is instantaneously at rest in the subsequent motion.

(6)

Q1

(Total 6 marks)

Leave blank

2. A car of mass 1200 kg moves along a straight horizontal road with a constant speed of $24\ \text{m s}^{-1}$. The resistance to motion of the car has magnitude 600 N.

(a) Find, in kW, the rate at which the engine of the car is working.

(2)

The car now moves up a hill inclined at α to the horizontal, where $\sin \alpha = \frac{1}{28}$. The resistance to motion of the car from non-gravitational forces remains of magnitude 600 N. The engine of the car now works at a rate of 30 kW.

(b) Find the acceleration of the car when its speed is $20\ \text{m s}^{-1}$.

(4)

Leave blank

3. A cricket ball of mass 0.5 kg is struck by a bat. Immediately before being struck, the velocity of the ball is $(-30\mathbf{i})$ m s^{-1}. Immediately after being struck, the velocity of the ball is $(16\mathbf{i} + 20\mathbf{j})$ m s^{-1}.

(a) Find the magnitude of the impulse exerted on the ball by the bat.

(4)

In the subsequent motion, the position vector of the ball is $\mathbf{r}$ metres at time t seconds. In a model of the situation, it is assumed that $\mathbf{r} = [16t\mathbf{i} + (20t - 5t^2)\mathbf{j}]$. Using this model,

(b) find the speed of the ball when $t = 3$.

(4)

N 2 2 3 3 2 A 0 6 2 0

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4. **Figure 1**

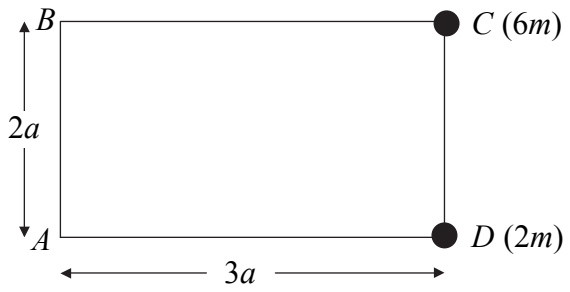

Figure 1 shows four uniform rods joined to form a rigid rectangular framework $ABCD$, where $AB = CD = 2a$, and $BC = AD = 3a$. Each rod has mass m. Particles, of mass $6m$ and $2m$, are attached to the framework at points C and D respectively.

(a) Find the distance of the centre of mass of the loaded framework from

(i) AB,

(ii) AD.

(7)

The loaded framework is freely suspended from B and hangs in equilibrium.

(b) Find the angle which BC makes with the vertical.

(3)

N 2 2 3 3 2 A 0 8 2 0

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Question 4 continued

(Total 10 marks)

Q4

Leave blank

5. A vertical cliff is 73.5 m high. Two stones A and B are projected simultaneously. Stone A is projected horizontally from the top of the cliff with speed $28\,\text{m s}^{-1}$. Stone B is projected from the bottom of the cliff with speed $35\,\text{m s}^{-1}$ at an angle α above the horizontal. The stones move freely under gravity in the same vertical plane and collide in mid-air. By considering the horizontal motion of each stone,

(a) prove that $\cos\alpha = \frac{4}{5}$.

(4)

(b) Find the time which elapses between the instant when the stones are projected and the instant when they collide.

(4)

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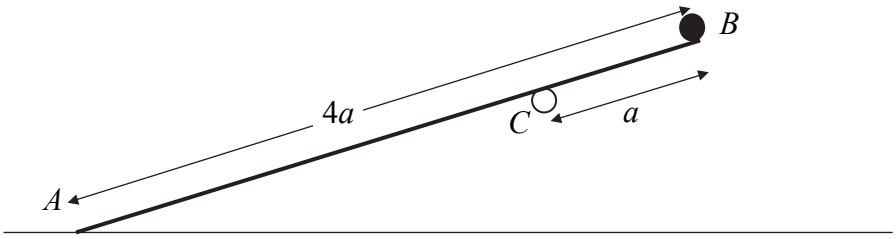
6. **Figure 2**



A wooden plank AB has mass $4m$ and length $4a$. The end A of the plank lies on rough horizontal ground. A small stone of mass m is attached to the plank at B. The plank is resting on a small smooth horizontal peg C, where $BC = a$, as shown in Figure 2. The plank is in equilibrium making an angle α with the horizontal, where $\tan\alpha = \frac{3}{4}$. The coefficient of friction between the plank and the ground is μ. The plank is modelled as a uniform rod lying in a vertical plane perpendicular to the peg, and the stone as a particle. Show that

(a) the reaction of the peg on the plank has magnitude $\frac{16}{5}mg$,

(3)

(b) $\mu \geqslant \frac{48}{61}$.

(6)

(c) State how you have used the information that the peg is smooth.

(1)

N 2 2 3 3 2 A 0 1 2 2 0

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Question 6 continued

Q6

(Total 10 marks)

N 2 2 3 3 2 A 0 1 3 2 0

Leave blank

7. A particle P has mass 4 kg. It is projected from a point A up a line of greatest slope of a rough plane inclined at an angle α to the horizontal, where $\tan\alpha = \frac{3}{4}$. The coefficient of friction between P and the plane is $\frac{2}{7}$. The particle comes to rest instantaneously at the point B on the plane, where $AB = 2.5$ m. It then moves back down the plane to A.

(a) Find the work done by friction as P moves from A to B.

(4)

(b) Using the work-energy principle, find the speed with which P is projected from A.

(4)

(c) Find the speed of P when it returns to A.

(4)

Leave blank

8. Two particles A and B move on a smooth horizontal table. The mass of A is m, and the mass of B is $4m$. Initially A is moving with speed u when it collides directly with B, which is at rest on the table. As a result of the collision, the direction of motion of A is reversed. The coefficient of restitution between the particles is e.

(a) Find expressions for the speed of A and the speed of B immediately after the collision.
(7)

In the subsequent motion, B strikes a smooth vertical wall and rebounds. The wall is perpendicular to the direction of motion of B. The coefficient of restitution between B and the wall is $\frac{4}{5}$. Given that there is a second collision between A and B,

(b) show that $\frac{1}{4} < e < \frac{9}{16}$.
(5)

Given that $e = \frac{1}{2}$,

(c) find the total kinetic energy lost in the first collision between A and B.
(3)

Leave blank

Question 8 continued