Edexcel Maths M2

Past Paper Pack

2005-2013

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

Friday 24 June 2005 – Morning

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
2	
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Total	

Materials required for examination	Items included with question papers
Mathematical Formulae (Lilac or Green)	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, initials and signature.
You must write your answers to each question in the space following the question.
Whenever a numerical value of g is required, take $g = 9.8 \text{ m s}^{-2}$.
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.
The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
Full marks may be obtained for answers to ALL questions.
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 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 car of mass 1200 kg moves along a straight horizontal road. The resistance to motion of the car from non-gravitational forces is of constant magnitude 600 N. The car moves with constant speed and the engine of the car is working at a rate of 21 kW.

(a) Find the speed of the car.

(3)

The car moves up a hill inclined at an angle α to the horizontal, where $\sin\alpha = \frac{1}{14}$.

The car's engine continues to work at 21 kW, and the resistance to motion from non-gravitational forces remains of magnitude 600 N.

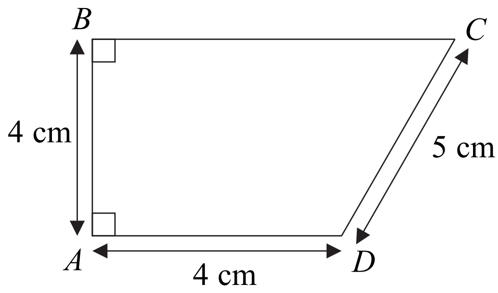
(b) Find the constant speed at which the car can move up the hill.

(4)

Leave blank

2.

Figure 1



A thin uniform wire, of total length 20 cm, is bent to form a frame. The frame is in the shape of a trapezium *ABCD*, where *AB* = *AD* = 4 cm, *CD* = 5 cm, and *AB* is perpendicular to *BC* and *AD*, as shown in Figure 1.

(a) Find the distance of the centre of mass of the frame from *AB*.

(5)

The frame has mass *M*. A particle of mass *kM* is attached to the frame at *C*. When the frame is freely suspended from the mid-point of *BC*, the frame hangs in equilibrium with *BC* horizontal.

(b) Find the value of *k*.

(3)

Leave blank

3. A particle P moves in a horizontal plane. At time t seconds, the position vector of P is $\mathbf{r}$ metres relative to a fixed origin O, and $\mathbf{r}$ is given by

$$\mathbf{r} = (18t - 4t^3)\mathbf{i} + ct^2\mathbf{j},$$

where c is a positive constant. When $t = 1.5$, the speed of P is 15 m s^{-1}. Find

(a) the value of c,

(6)

(b) the acceleration of P when $t = 1.5$.

(3)

Leave blank

4. A darts player throws darts at a dart board which hangs vertically. The motion of a dart is modelled as that of a particle moving freely under gravity. The darts move in a vertical plane which is perpendicular to the plane of the dart board. A dart is thrown horizontally with speed 12.6 m s^{-1}. It hits the board at a point which is 10 cm below the level from which it was thrown.

(a) Find the horizontal distance from the point where the dart was thrown to the dart board.

(4)

The darts player moves his position. He now throws a dart from a point which is at a horizontal distance of 2.5 m from the board. He throws the dart at an angle of elevation α to the horizontal, where $\tan\alpha = \frac{7}{24}$. This dart hits the board at a point which is at the same level as the point from which it was thrown.

(b) Find the speed with which the dart is thrown.

(6)

Leave blank

Question 4 continued

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5. Two small spheres A and B have mass $3m$ and $2m$ respectively. They are moving towards each other in opposite directions on a smooth horizontal plane, both with speed $2u$, when they collide directly. As a result of the collision, the direction of motion of B is reversed and its speed is unchanged.

(a) Find the coefficient of restitution between the spheres.

(7)

Subsequently, B collides directly with another small sphere C of mass $5m$ which is at rest. The coefficient of restitution between B and C is $\frac{3}{5}$.

(b) Show that, after B collides with C, there will be no further collisions between the spheres.

(7)

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Question 5 continued

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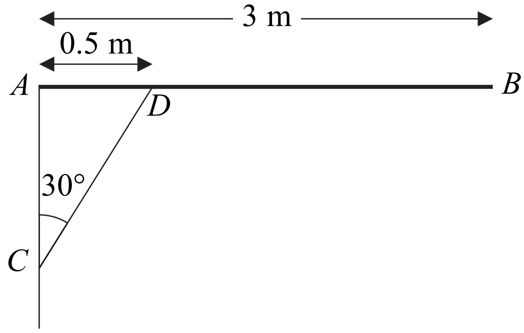
6.

Figure 2



A uniform pole *AB*, of mass 30 kg and length 3 m, is smoothly hinged to a vertical wall at one end *A*. The pole is held in equilibrium in a horizontal position by a light rod *CD*. One end *C* of the rod is fixed to the wall vertically below *A*. The other end *D* is freely jointed to the pole so that $\angle ACD = 30°$ and $AD = 0.5$ m, as shown in Figure 2. Find

(a) the thrust in the rod *CD*,

(4)

(b) the magnitude of the force exerted by the wall on the pole at *A*.

(6)

The rod *CD* is removed and replaced by a longer light rod *CM*, where *M* is the mid-point of *AB*. The rod is freely jointed to the pole at *M*. The pole *AB* remains in equilibrium in a horizontal position.

(c) Show that the force exerted by the wall on the pole at *A* now acts horizontally.

(2)

Leave blank

Question 6 continued

Leave blank

7. At a demolition site, bricks slide down a straight chute into a container. The chute is rough and is inclined at an angle of 30° to the horizontal. The distance travelled down the chute by each brick is 8 m. A brick of mass 3 kg is released from rest at the top of the chute. When it reaches the bottom of the chute, its speed is 5 m s^{-1}.

(a) Find the potential energy lost by the brick in moving down the chute.
(2)

(b) By using the work-energy principle, or otherwise, find the constant frictional force acting on the brick as it moves down the chute.
(5)

(c) Hence find the coefficient of friction between the brick and the chute.
(3)

Another brick of mass 3 kg slides down the chute. This brick is given an initial speed of 2 m s^{-1} at the top of the chute.

(d) Find the speed of this brick when it reaches the bottom of the chute.
(5)

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Question 7 continued

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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	
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Total	

Materials required for examination
Mathematical Formulae (Green)

Items included with question papers
Nil

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If you need more space to complete your answers to any question, use additional sheets.
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When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information for Candidates

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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

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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 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 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)

Leave blank

4.

Figure 1

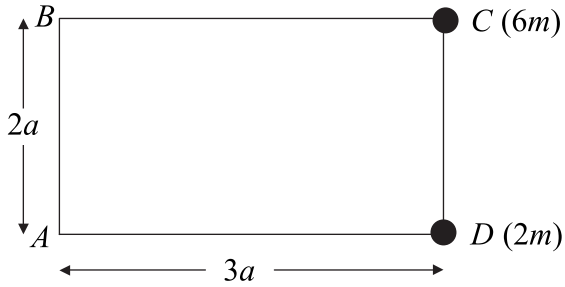

Figure 1 shows four uniform rods joined to form a rigid rectangular framework $ABCD$, where $AB = CD = 2a$, and $BC = AD = 3a$. Each rod has mass m. Particles, of mass $6m$ and $2m$, are attached to the framework at points C and D respectively.

(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)

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Question 4 continued

Q4

(Total 10 marks)

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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 m s^{-1}. Stone B is projected from the bottom of the cliff with speed 35 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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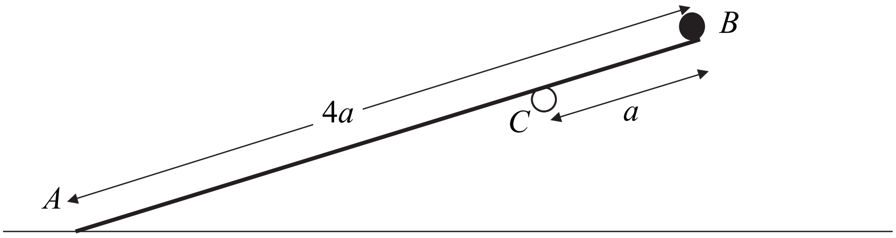
6.

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)

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Question 6 continued

(Total 10 marks)

Q6

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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)

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Question 8 continued

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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

Thursday 25 January 2007 – Morning

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
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Total	

Materials required for examination	Items included with question papers
Mathematical Formulae (Green)	Nil

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There are 7 questions in this question paper. The total mark for this paper is 75.
There are 16 pages in this question paper. Any blank pages are indicated.

Advice to Candidates

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1. A particle of mass 0.8 kg is moving in a straight line on a rough horizontal plane. The speed of the particle is reduced from 15 m s^{-1} to 10 m s^{-1} as the particle moves 20 m. Assuming that the only resistance to motion is the friction between the particle and the plane, find

(a) the work done by friction in reducing the speed of the particle from 15 m s^{-1} to 10 m s^{-1},

(2)

(b) the coefficient of friction between the particle and the plane.

(4)

Leave blank

2. A car of mass 800 kg is moving at a constant speed of 15 m s^{-1} down a straight road inclined at an angle α to the horizontal, where $\sin \alpha = \frac{1}{24}$. The resistance to motion from non-gravitational forces is modelled as a constant force of magnitude 900 N.

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

(4)

When the car is travelling down the road at 15 m s^{-1}, the engine is switched off. The car comes to rest in time T seconds after the engine is switched off. The resistance to motion from non-gravitational forces is again modelled as a constant force of magnitude 900 N.

(b) Find the value of T.

(4)

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3. **Figure 1**

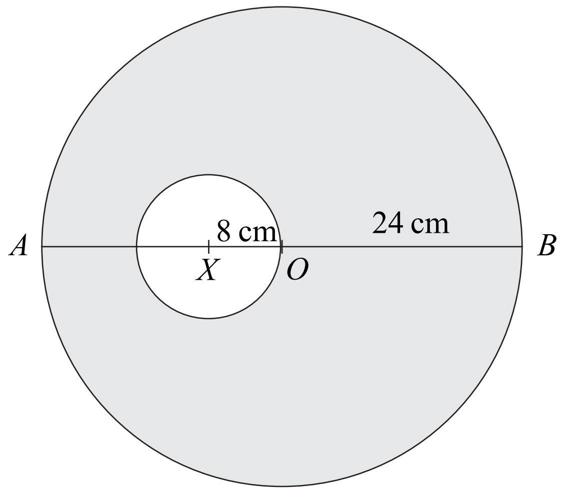

Figure 1 shows a template T made by removing a circular disc, of centre X and radius 8 cm, from a uniform circular lamina, of centre O and radius 24 cm. The point X lies on the diameter AOB of the lamina and AX = 16 cm. The centre of mass of T is at the point G.

(a) Find AG.

(6)

The template T is free to rotate about a smooth fixed horizontal axis, perpendicular to the plane of T, which passes through the mid-point of OB. A small stud of mass $\frac{1}{4}m$ is fixed at B, and T and the stud are in equilibrium with AB horizontal. Modelling the stud as a particle,

(b) find the mass of T in terms of m.

(4)

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Question 3 continued

(Total 10 marks)

Q3

N 2 3 5 5 9 A 0 7 1 6

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4. A particle P of mass m is moving in a straight line on a smooth horizontal table. Another particle Q of mass km is at rest on the table. The particle P collides directly with Q. The direction of motion of P is reversed by the collision. After the collision, the speed of P is v and the speed of Q is $3v$. The coefficient of restitution between P and Q is $\frac{1}{2}$.

(a) Find, in terms of v only, the speed of P before the collision.

(3)

(b) Find the value of k.

(3)

After being struck by P, the particle Q collides directly with a particle R of mass $11m$ which is at rest on the table. After this second collision, Q and R have the same speed and are moving in opposite directions. Show that

(c) the coefficient of restitution between Q and R is $\frac{3}{4}$,

(4)

(d) there will be a further collision between P and Q.

(2)

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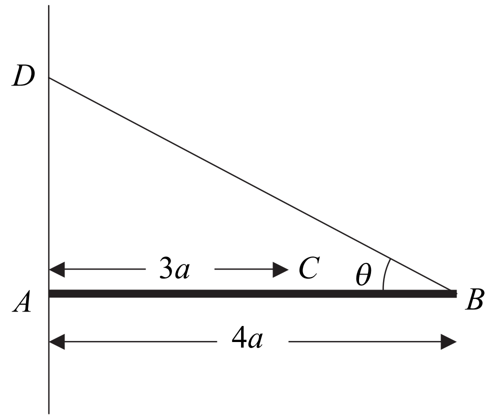
5.

Figure 2



A horizontal uniform rod AB has mass m and length $4a$. The end A rests against a rough vertical wall. A particle of mass $2m$ is attached to the rod at the point C, where $AC = 3a$. One end of a light inextensible string BD is attached to the rod at B and the other end is attached to the wall at a point D, where D is vertically above A. The rod is in equilibrium in a vertical plane perpendicular to the wall. The string is inclined at an angle θ to the horizontal, where $\tan\theta = \frac{3}{4}$, as shown in Figure 2.

(a) Find the tension in the string.

(5)

(b) Show that the horizontal component of the force exerted by the wall on the rod has magnitude $\frac{8}{3}mg$.

(3)

The coefficient of friction between the wall and the rod is μ. Given that the rod is in limiting equilibrium,

(c) find the value of μ.

(4)

Leave blank

Question 5 continued

Q5

(Total 12 marks)

Leave blank

6. A particle P of mass 0.5 kg is moving under the action of a single force $\mathbf{F}$ newtons. At time t seconds, $\mathbf{F} = (1.5t^2 - 3)\mathbf{i} + 2t\mathbf{j}$. When $t = 2$, the velocity of P is $(-4\mathbf{i} + 5\mathbf{j})$ m s^{-1}.

(a) Find the acceleration of P at time t seconds.

(2)

(b) Show that, when $t = 3$, the velocity of P is $(9\mathbf{i} + 15\mathbf{j})$ m s^{-1}.

(5)

When $t = 3$, the particle P receives an impulse $\mathbf{Q}$ N s. Immediately after the impulse the velocity of P is $(-3\mathbf{i} + 20\mathbf{j})$ m s^{-1}. Find

(c) the magnitude of $\mathbf{Q}$,

(3)

(d) the angle between $\mathbf{Q}$ and $\mathbf{i}$.

(3)

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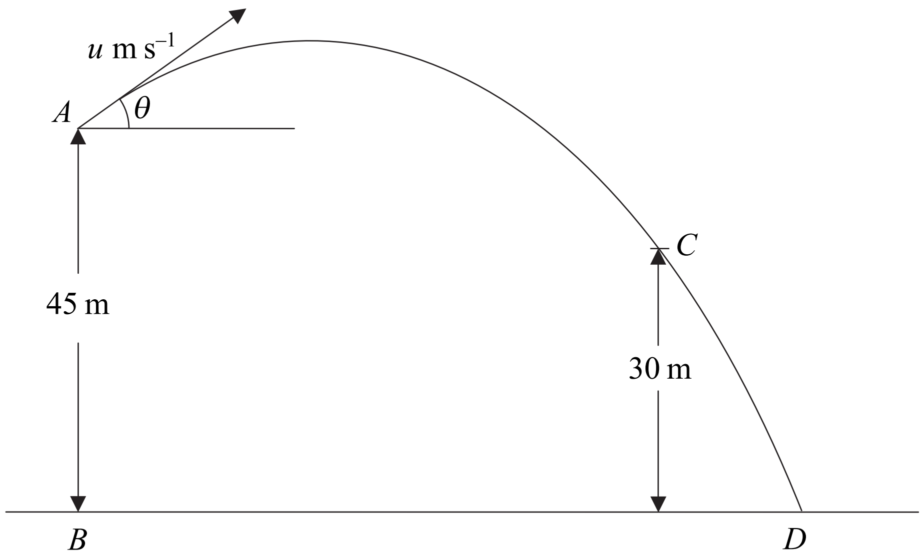
7.

Figure 3



A particle P is projected from a point A with speed u m s^{-1} at an angle of elevation θ, where $\cos\theta = \frac{4}{5}$. The point B, on horizontal ground, is vertically below A and $AB = 45$ m. After projection, P moves freely under gravity passing through a point C, 30 m above the ground, before striking the ground at the point D, as shown in Figure 3.

Given that P passes through C with speed 24.5 m s^{-1},

(a) using conservation of energy, or otherwise, show that $u = 17.5$,

(4)

(b) find the size of the angle which the velocity of P makes with the horizontal as P passes through C,

(3)

(c) find the distance BD.

(7)

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Question 7 continued

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Question 7 continued

Q7

(Total 14 marks)

TOTAL FOR PAPER: 75 MARKS

END

June 2007

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

Thursday 7 June 2007 – Morning

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
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Materials required for examination	Items included with question papers
Mathematical Formulae (Green)	Nil

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Instructions to Candidates

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1. A cyclist and his bicycle have a combined mass of 90 kg. He rides on a straight road up a hill inclined at an angle α to the horizontal, where $\sin \alpha = \frac{1}{21}$. He works at a constant rate of 444 W and cycles up the hill at a constant speed of 6 m s^{-1}.

Find the magnitude of the resistance to motion from non-gravitational forces as he cycles up the hill.

(4)

Leave blank

2. A particle P of mass 0.5 kg moves under the action of a single force $\mathbf{F}$ newtons. At time t seconds, the velocity $\mathbf{v}$ m s^{-1} of P is given by

$$\mathbf{v} = 3t^2\mathbf{i} + (1 - 4t)\mathbf{j}.$$

Find

(a) the acceleration of P at time t seconds,

(2)

(b) the magnitude of $\mathbf{F}$ when $t = 2$.

(4)

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3.

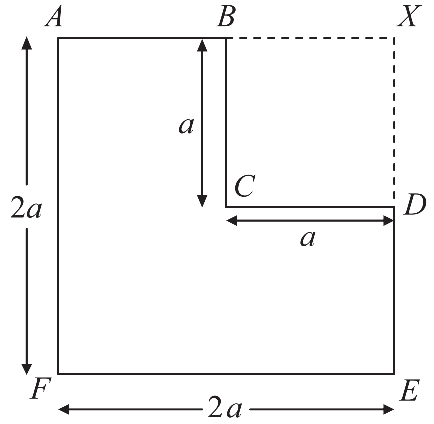

Figure 1

A uniform lamina *ABCDEF* is formed by taking a uniform sheet of card in the form of a square *AXEF*, of side $2a$, and removing the square *BXDC* of side a, where *B* and *D* are the mid-points of *AX* and *XE* respectively, as shown in Figure 1.

(a) Find the distance of the centre of mass of the lamina from *AF*.

(4)

The lamina is freely suspended from *A* and hangs in equilibrium.

(b) Find, in degrees to one decimal place, the angle which *AF* makes with the vertical.

(4)

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Question 3 continued

Q3

(Total 8 marks)

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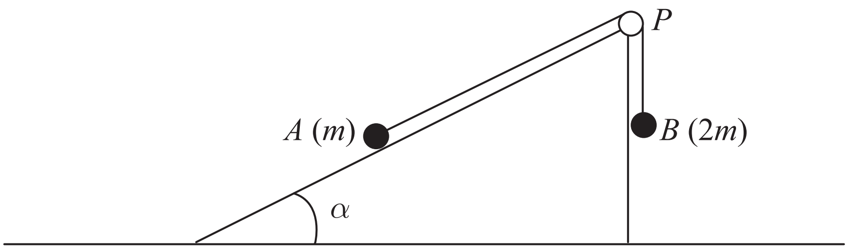

Figure 2

Two particles A and B, of mass m and $2m$ respectively, are attached to the ends of a light inextensible string. The particle A lies on a rough plane inclined at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$. The string passes over a small light smooth pulley P fixed at the top of the plane. The particle B hangs freely below P, as shown in Figure 2. The particles are released from rest with the string taut and the section of the string from A to P parallel to a line of greatest slope of the plane. The coefficient of friction between A and the plane is $\frac{5}{8}$. When each particle has moved a distance h, B has not reached the ground and A has not reached P.

(a) Find an expression for the potential energy lost by the system when each particle has moved a distance h.

(2)

When each particle has moved a distance h, they are moving with speed v. Using the work-energy principle,

(b) find an expression for v^2, giving your answer in the form kgh, where k is a number.

(5)

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Question 4 continued

(Total 7 marks)

Q4

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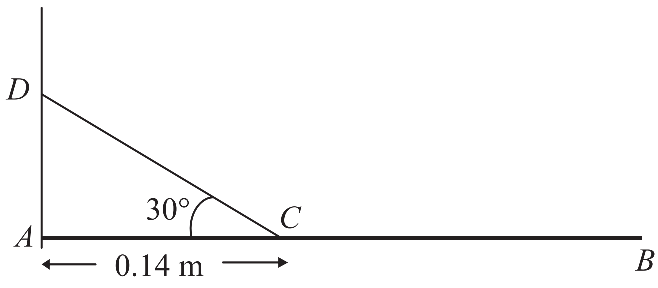

Figure 3

A uniform beam AB of mass 2 kg is freely hinged at one end A to a vertical wall. The beam is held in equilibrium in a horizontal position by a rope which is attached to a point C on the beam, where $AC = 0.14$ m. The rope is attached to the point D on the wall vertically above A, where $\angle ACD = 30°$, as shown in Figure 3. The beam is modelled as a uniform rod and the rope as a light inextensible string. The tension in the rope is 63 N.

Find

(a) the length of AB,

(4)

(b) the magnitude of the resultant reaction of the hinge on the beam at A.

(5)

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Question 5 continued

Q5

(Total 9 marks)

N 2 6 1 1 5 A 0 1 1 2 4

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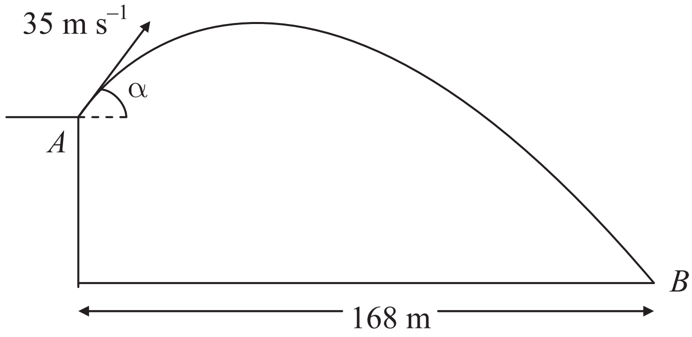

Figure 4

A golf ball P is projected with speed 35 m s^{-1} from a point A on a cliff above horizontal ground. The angle of projection is α to the horizontal, where $\tan \alpha = \frac{4}{3}$. The ball moves freely under gravity and hits the ground at the point B, as shown in Figure 4.

(a) Find the greatest height of P above the level of A.

(3)

The horizontal distance from A to B is 168 m.

(b) Find the height of A above the ground.

(6)

By considering energy, or otherwise,

(c) find the speed of P as it hits the ground at B.

(3)

Leave blank

Question 6 continued

Leave blank

7. Two small spheres P and Q of equal radius have masses m and $5m$ respectively. They lie on a smooth horizontal table. Sphere P is moving with speed u when it collides directly with sphere Q which is at rest. The coefficient of restitution between the spheres is e, where $e > \frac{1}{5}$.

(a) (i) Show that the speed of P immediately after the collision is $\frac{u}{6}(5e - 1)$.

(ii) Find an expression for the speed of Q immediately after the collision, giving your answer in the form λu, where λ is in terms of e.

(6)

Three small spheres A, B and C of equal radius lie at rest in a straight line on a smooth horizontal table, with B between A and C. The spheres A and C each have mass $5m$, and the mass of B is m. Sphere B is projected towards C with speed u. The coefficient of restitution between each pair of spheres is $\frac{4}{5}$.

(b) Show that, after B and C have collided, there is a collision between B and A.

(3)

(c) Determine whether, after B and A have collided, there is a further collision between B and C.

(4)

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Question 7 continued

N 2 6 1 1 5 A 0 1 7 2 4

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8. A particle P moves on the x-axis. At time t seconds the velocity of P is v m s^{-1} in the direction of x increasing, where v is given by

$$v = \begin{cases} 8t - \frac{3}{2}t^2, & 0 \leqslant t \leqslant 4, \\ 16 - 2t, & t > 4. \end{cases}$$

When $t = 0$, P is at the origin O.

Find

(a) the greatest speed of P in the interval $0 \leqslant t \leqslant 4$,

(4)

(b) the distance of P from O when $t = 4$,

(3)

(c) the time at which P is instantaneously at rest for $t > 4$,

(1)

(d) the total distance travelled by P in the first 10 s of its motion.

(8)

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Question 8 continued

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

Thursday 24 January 2008 – Morning

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
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Materials required for examination	**Items included with question papers**
Mathematical Formulae (Green)	Nil

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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

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Answers without working may not gain full credit.

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1. A parcel of mass 2.5 kg is moving in a straight line on a smooth horizontal floor. Initially the parcel is moving with speed 8 m s^{-1}. The parcel is brought to rest in a distance of 20 m by a constant horizontal force of magnitude R newtons. Modelling the parcel as a particle, find

(a) the kinetic energy lost by the parcel in coming to rest,

(2)

(b) the value of R.

(3)

Leave blank

2. At time t seconds ($t \geqslant 0$), a particle P has position vector **p** metres, with respect to a fixed origin O, where

$$\mathbf{p} = (3t^2 - 6t + 4)\mathbf{i} + (3t^3 - 4t)\mathbf{j}.$$

Find

(a) the velocity of P at time t seconds,

(2)

(b) the value of t when P is moving parallel to the vector **i**.

(3)

When $t = 1$, the particle P receives an impulse of $(2\mathbf{i} - 6\mathbf{j})$ N s. Given that the mass of P is 0.5 kg,

(c) find the velocity of P immediately after the impulse.

(4)

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3. A car of mass 1000 kg is moving at a constant speed of 16 m s^{-1} up a straight road inclined at an angle θ to the horizontal. The rate of working of the engine of the car is 20 kW and the resistance to motion from non-gravitational forces is modelled as a constant force of magnitude 550 N.

(a) Show that $\sin\theta = \frac{1}{14}$.

(5)

When the car is travelling up the road at 16 m s^{-1}, the engine is switched off. The car comes to rest, without braking, having moved a distance y metres from the point where the engine was switched off. The resistance to motion from non-gravitational forces is again modelled as a constant force of magnitude 550 N.

(b) Find the value of y.

(4)

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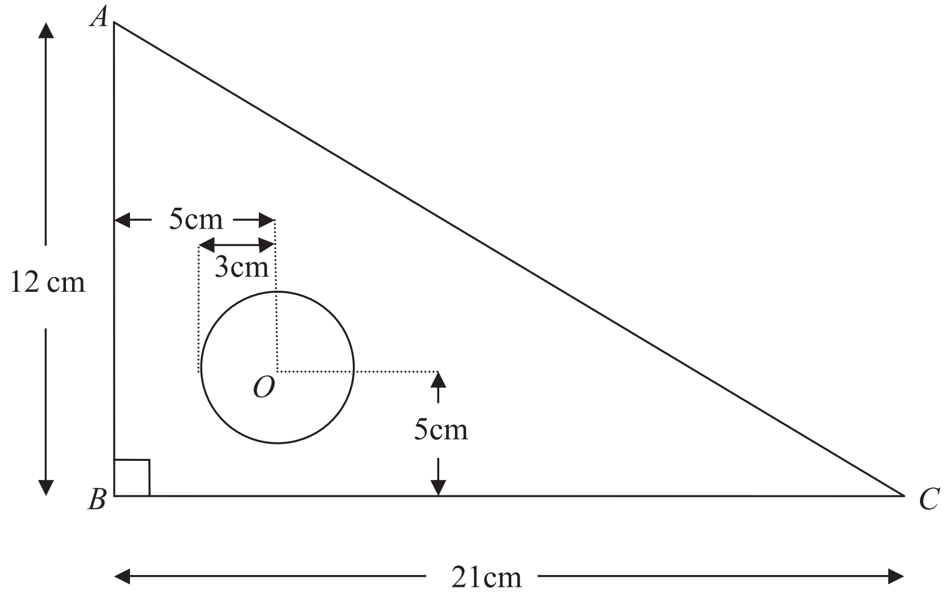

Figure 1

A set square S is made by removing a circle of centre O and radius 3 cm from a triangular piece of wood. The piece of wood is modelled as a uniform triangular lamina ABC, with $\angle ABC = 90°$, $AB = 12$ cm and $BC = 21$ cm. The point O is 5 cm from AB and 5 cm from BC, as shown in Figure 1.

(a) Find the distance of the centre of mass of S from

(i) AB,

(ii) BC.

(9)

The set square is freely suspended from C and hangs in equilibrium.

(b) Find, to the nearest degree, the angle between CB and the vertical.

(3)

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Question 4 continued

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Question 4 continued

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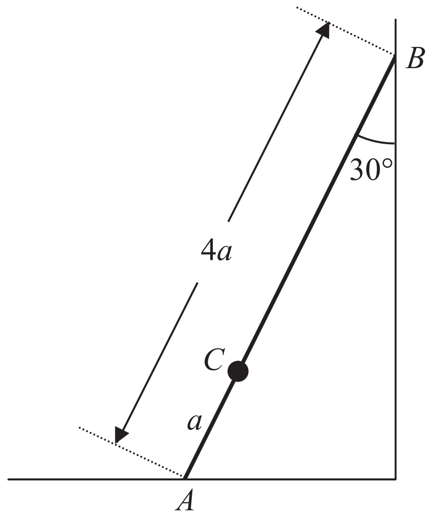

Figure 2

A ladder AB, of mass m and length $4a$, has one end A resting on rough horizontal ground. The other end B rests against a smooth vertical wall. A load of mass $3m$ is fixed on the ladder at the point C, where $AC = a$. The ladder is modelled as a uniform rod in a vertical plane perpendicular to the wall and the load is modelled as a particle. The ladder rests in limiting equilibrium making an angle of 30° with the wall, as shown in Figure 2.

Find the coefficient of friction between the ladder and the ground.

(10)

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Question 5 continued

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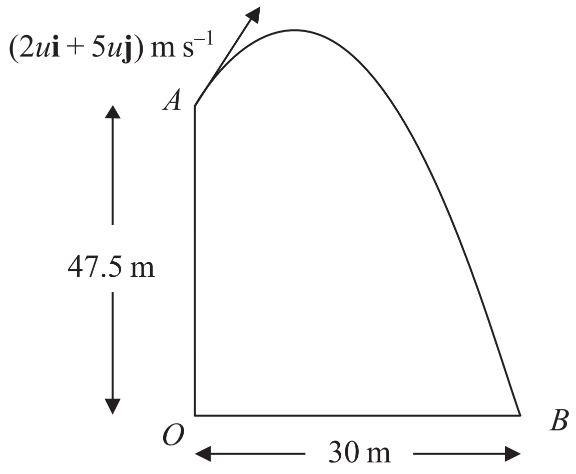

Figure 3

[*In this question, the unit vectors* **i** *and* **j** *are in a vertical plane,* **i** *being horizontal and* **j** *being vertical.*]

A particle P is projected from the point A which has position vector 47.5**j** metres with respect to a fixed origin O. The velocity of projection of P is $(2u\mathbf{i} + 5u\mathbf{j})$ m s^{-1}. The particle moves freely under gravity passing through the point B with position vector 30**i** metres, as shown in Figure 3.

(a) Show that the time taken for P to move from A to B is 5 s.

(6)

(b) Find the value of u.

(2)

(c) Find the speed of P at B.

(5)

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Question 6 continued

N 2 5 2 5 2 A 0 1 7 2 4

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7. A particle P of mass $2m$ is moving with speed $2u$ in a straight line on a smooth horizontal plane. A particle Q of mass $3m$ is moving with speed u in the same direction as P. The particles collide directly. The coefficient of restitution between P and Q is $\frac{1}{2}$.

(a) Show that the speed of Q immediately after the collision is $\frac{8}{5}u$.

(5)

(b) Find the total kinetic energy lost in the collision.

(5)

After the collision between P and Q, the particle Q collides directly with a particle R of mass m which is at rest on the plane. The coefficient of restitution between Q and R is e.

(c) Calculate the range of values of e for which there will be a second collision between P and Q.

(7)

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Question 7 continued

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

Wednesday 21 May 2008 – Afternoon

Time: 1 hour 30 minutes

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Team Leader's use only

Question Number	Leave Blank
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Materials required for examination	**Items included with question papers**
Mathematical Formulae (Green)	Nil

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Answer ALL the questions.
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If you need more space to complete your answers to any question, use additional sheets.
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Information for Candidates

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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

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1. A lorry of mass 2000 kg is moving down a straight road inclined at angle α to the horizontal, where $\sin\alpha = \frac{1}{25}$. The resistance to motion is modelled as a constant force of magnitude 1600 N. The lorry is moving at a constant speed of 14 m s^{-1}.

Find, in kW, the rate at which the lorry's engine is working.

(6)

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2. A particle A of mass $4m$ is moving with speed $3u$ in a straight line on a smooth horizontal table. The particle A collides directly with a particle B of mass $3m$ moving with speed $2u$ in the same direction as A. The coefficient of restitution between A and B is e. Immediately after the collision the speed of B is $4eu$.

(a) Show that $e = \frac{3}{4}$.

(5)

(b) Find the total kinetic energy lost in the collision.

(4)

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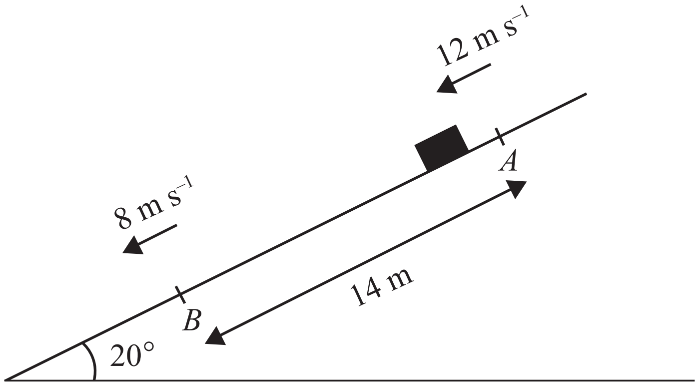

Figure 1

A package of mass 3.5 kg is sliding down a ramp. The package is modelled as a particle and the ramp as a rough plane inclined at an angle of 20° to the horizontal. The package slides down a line of greatest slope of the plane from a point A to a point B, where AB = 14 m. At A the package has speed 12 m s^{-1} and at B the package has speed 8 m s^{-1}, as shown in Figure 1. Find

(a) the total energy lost by the package in travelling from A to B,

(5)

(b) the coefficient of friction between the package and the ramp.

(5)

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Question 3 continued

(Total 10 marks)

Q3

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4. A particle P of mass 0.5 kg is moving under the action of a single force $\mathbf{F}$ newtons. At time t seconds,

$$\mathbf{F} = (6t - 5)\,\mathbf{i} + (t^2 - 2t)\,\mathbf{j}.$$

The velocity of P at time t seconds is $\mathbf{v}$ m s^{-1}. When $t = 0$, $\mathbf{v} = \mathbf{i} - 4\mathbf{j}$.

(a) Find $\mathbf{v}$ at time t seconds.

(6)

When $t = 3$, the particle P receives an impulse $(-5\mathbf{i} + 12\mathbf{j})$ N s.

(b) Find the speed of P immediately after it receives the impulse.

(6)

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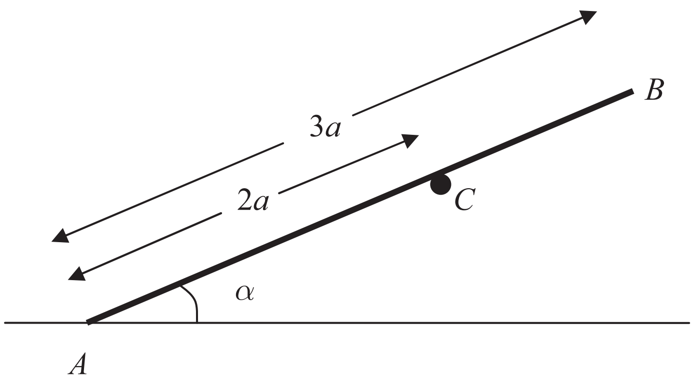

Figure 2

A plank rests in equilibrium against a fixed horizontal pole. The plank is modelled as a uniform rod AB and the pole as a smooth horizontal peg perpendicular to the vertical plane containing AB. The rod has length $3a$ and weight W and rests on the peg at C, where $AC = 2a$. The end A of the rod rests on rough horizontal ground and AB makes an angle α with the ground, as shown in Figure 2.

(a) Show that the normal reaction on the rod at A is $\frac{1}{4}(4 - 3\cos^2 \alpha)W$.

(6)

Given that the rod is in limiting equilibrium and that $\cos \alpha = \frac{2}{3}$,

(b) find the coefficient of friction between the rod and the ground.

(5)

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Question 5 continued

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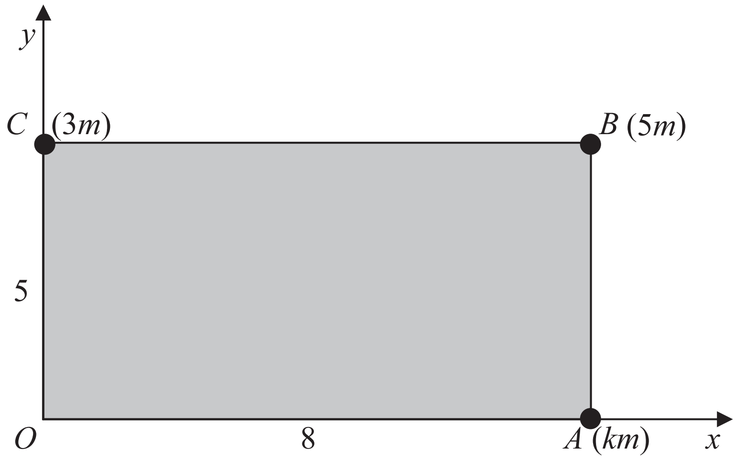

Figure 3

Figure 3 shows a rectangular lamina *OABC*. The coordinates of *O*, *A*, *B* and *C* are (0, 0), (8, 0), (8, 5) and (0, 5) respectively. Particles of mass km, $5m$ and $3m$ are attached to the lamina at *A*, *B* and *C* respectively.

The x-coordinate of the centre of mass of the three particles *without the lamina* is 6.4.

(a) Show that $k = 7$.

(4)

The lamina *OABC* is uniform and has mass $12m$.

(b) Find the coordinates of the centre of mass of the combined system consisting of the three particles and the lamina.

(6)

The combined system is freely suspended from *O* and hangs at rest.

(c) Find the angle between *OC* and the horizontal.

(3)

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Question 6 continued

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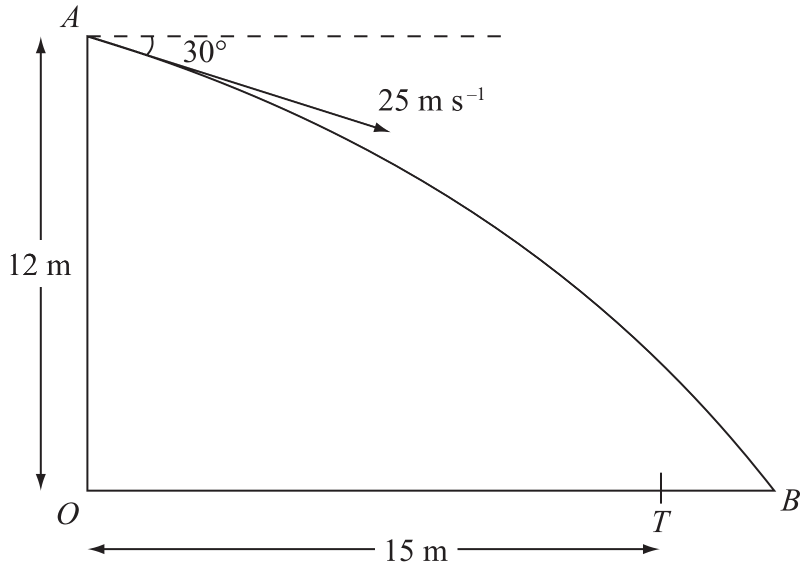

Figure 4

A ball is thrown from a point A at a target, which is on horizontal ground. The point A is 12 m above the point O on the ground. The ball is thrown from A with speed 25 m s^{-1} at an angle of 30° below the horizontal. The ball is modelled as a particle and the target as a point T. The distance OT is 15 m. The ball misses the target and hits the ground at the point B, where OTB is a straight line, as shown in Figure 4. Find

(a) the time taken by the ball to travel from A to B,

(5)

(b) the distance TB.

(4)

The point X is on the path of the ball vertically above T.

(c) Find the speed of the ball at X.

(5)

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Question 7 continued

Q7

(Total 14 marks)

TOTAL FOR PAPER: 75 MARKS

END

Centre No.						Paper Reference	Surname	Initial(s)
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Paper Reference(s)

6678/01

Edexcel GCE

Mechanics M2

Advanced/Advanced Subsidiary

Thursday 29 January 2009 – Morning

Time: 1 hour 30 minutes

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Team Leader's use only

Question Number	Leave Blank
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Materials required for examination	Items included with question papers
Mathematical Formulae (Green)	Nil

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1. A car of mass 1500 kg is moving up a straight road, which is inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{14}$. The resistance to the motion of the car from non-gravitational forces is constant and is modelled as a single constant force of magnitude 650 N. The car's engine is working at a rate of 30 kW.

Find the acceleration of the car at the instant when its speed is 15 m s^{-1}.

(5)

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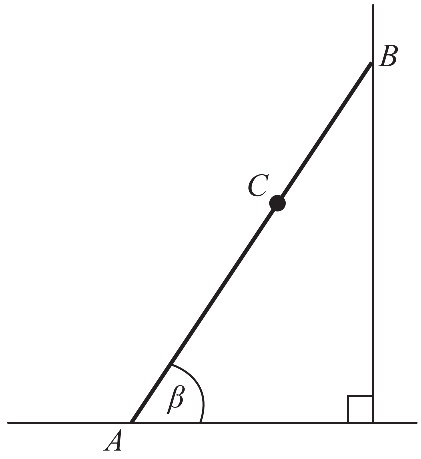

Figure 1

Figure 1 shows a ladder *AB*, of mass 25 kg and length 4 m, resting in equilibrium with one end *A* on rough horizontal ground and the other end *B* against a smooth vertical wall. The ladder is in a vertical plane perpendicular to the wall. The coefficient of friction between the ladder and the ground is $\frac{11}{25}$. The ladder makes an angle β with the ground. When Reece, who has mass 75 kg, stands at the point *C* on the ladder, where $AC = 2.8$ m, the ladder is on the point of slipping. The ladder is modelled as a uniform rod and Reece is modelled as a particle.

(a) Find the magnitude of the frictional force of the ground on the ladder.

(3)

(b) Find, to the nearest degree, the value of β.

(6)

(c) State how you have used the modelling assumption that Reece is a particle.

(1)

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Question 2 continued

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3. A block of mass 10 kg is pulled along a straight horizontal road by a constant horizontal force of magnitude 70 N in the direction of the road. The block moves in a straight line passing through two points A and B on the road, where $AB = 50$ m. The block is modelled as a particle and the road is modelled as a rough plane. The coefficient of friction between the block and the road is $\frac{4}{7}$.

(a) Calculate the work done against friction in moving the block from A to B.

(4)

The block passes through A with a speed of 2 m s^{-1}.

(b) Find the speed of the block at B.

(4)

Leave blank

4. A particle P moves along the x-axis in a straight line so that, at time t seconds, the velocity of P is v m s^{-1}, where

$$v = \begin{cases} 10t - 2t^2, & 0 \leqslant t \leqslant 6, \\ \dfrac{-432}{t^2}, & t > 6. \end{cases}$$

At $t = 0$, P is at the origin O. Find the displacement of P from O when

(a) $t = 6$,

(3)

(b) $t = 10$.

(5)

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Question 4 continued

Q4

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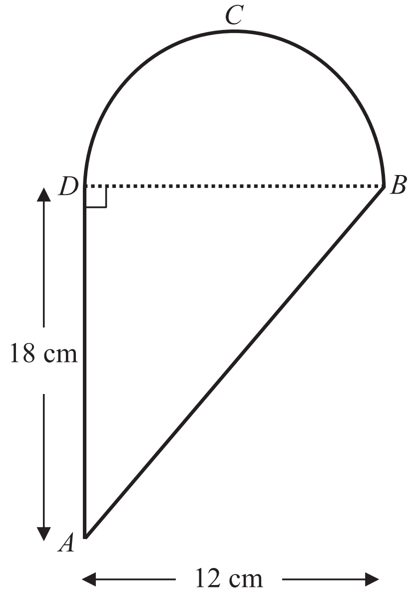

Figure 2

A uniform lamina *ABCD* is made by joining a uniform triangular lamina *ABD* to a uniform semi-circular lamina *DBC*, of the same material, along the edge *BD*, as shown in Figure 2. Triangle *ABD* is right-angled at *D* and *AD* = 18 cm. The semi-circle has diameter *BD* and *BD* = 12 cm.

(a) Show that, to 3 significant figures, the distance of the centre of mass of the lamina *ABCD* from *AD* is 4.69 cm.

(4)

Given that the centre of mass of a uniform semicircular lamina, radius *r*, is at a distance $\frac{4r}{3\pi}$ from the centre of the bounding diameter,

(b) find, in cm to 3 significant figures, the distance of the centre of mass of the lamina *ABCD* from *BD*.

(4)

The lamina is freely suspended from *B* and hangs in equilibrium.

(c) Find, to the nearest degree, the angle which *BD* makes with the vertical.

(4)

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Question 5 continued

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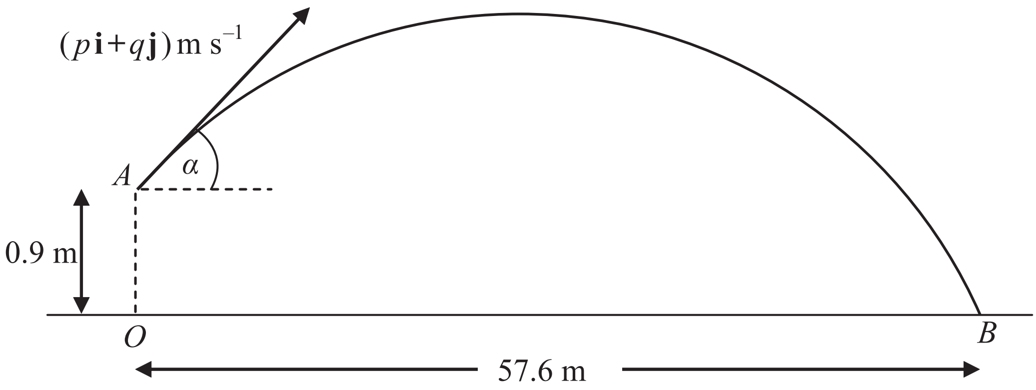

Figure 3

A cricket ball is hit from a point A with velocity of $(p\mathbf{i} + q\mathbf{j})$ m s^{-1}, at an angle α above the horizontal. The unit vectors $\mathbf{i}$ and $\mathbf{j}$ are respectively horizontal and vertically upwards. The point A is 0.9 m vertically above the point O, which is on horizontal ground.

The ball takes 3 seconds to travel from A to B, where B is on the ground and $OB = 57.6$ m, as shown in Figure 3. By modelling the motion of the cricket ball as that of a particle moving freely under gravity,

(a) find the value of p,

(2)

(b) show that $q = 14.4$,

(3)

(c) find the initial speed of the cricket ball,

(2)

(d) find the exact value of $\tan \alpha$.

(1)

(e) Find the length of time for which the cricket ball is at least 4 m above the ground.

(6)

(f) State an additional physical factor which may be taken into account in a refinement of the above model to make it more realistic.

(1)

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Question 6 continued

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7. A particle P of mass $3m$ is moving in a straight line with speed $2u$ on a smooth horizontal table. It collides directly with another particle Q of mass $2m$ which is moving with speed u in the opposite direction to P. The coefficient of restitution between P and Q is e.

(a) Show that the speed of Q immediately after the collision is $\frac{1}{5}(9e + 4)u$.

(5)

The speed of P immediately after the collision is $\frac{1}{2}u$.

(b) Show that $e = \frac{1}{4}$.

(4)

The collision between P and Q takes place at the point A. After the collision Q hits a smooth fixed vertical wall which is at right-angles to the direction of motion of Q. The distance from A to the wall is d.

(c) Show that P is a distance $\frac{3}{5}d$ from the wall at the instant when Q hits the wall.

(4)

Particle Q rebounds from the wall and moves so as to collide directly with particle P at the point B. Given that the coefficient of restitution between Q and the wall is $\frac{1}{5}$,

(d) find, in terms of d, the distance of the point B from the wall.

(4)

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Question 7 continued

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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

Friday 22 May 2009 – Morning

Time: 1 hour 30 minutes

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Question Number	Leave Blank
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Materials required for examination	Items included with question papers
Mathematical Formulae (Orange or Green)	Nil

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There are 28 pages in this question paper. Any blank pages are indicated.

Advice to Candidates

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Answers without working may not gain full credit.

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1. A particle of mass 0.25 kg is moving with velocity $(3\mathbf{i} + 7\mathbf{j})$ m s^{-1} when it receives the impulse $(5\mathbf{i} - 3\mathbf{j})$ N s.

Find the speed of the particle immediately after the impulse.

(5)

Leave blank

2. At time $t = 0$ a particle P leaves the origin O and moves along the x-axis. At time t seconds the velocity of P is v m s^{-1}, where

$$v = 8t - t^2 .$$

(a) Find the maximum value of v.

(4)

(b) Find the time taken for P to return to O.

(5)

Leave blank

3. A truck of mass of 300 kg moves along a straight horizontal road with a constant speed of 10 m s^{-1}. The resistance to motion of the truck has magnitude 120 N.

(a) Find the rate at which the engine of the truck is working.

(2)

On another occasion the truck moves at a constant speed up a hill inclined at θ to the horizontal, where $\sin\theta = \frac{1}{14}$. The resistance to motion of the truck from non-gravitational forces remains of magnitude 120 N. The rate at which the engine works is the same as in part (a).

(b) Find the speed of the truck.

(4)

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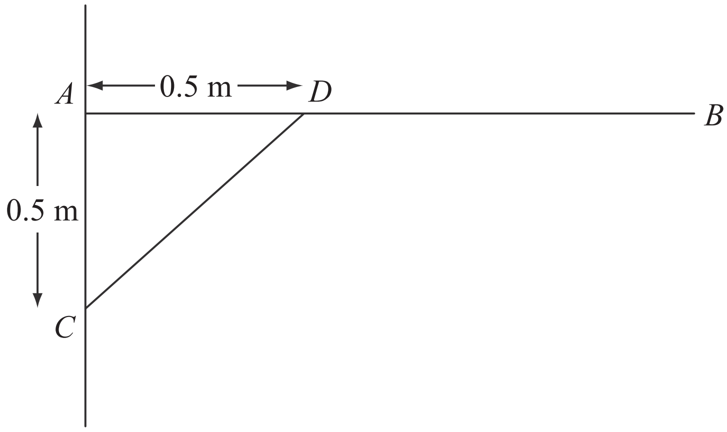

Figure 1

A uniform rod *AB*, of length 1.5 m and mass 3 kg, is smoothly hinged to a vertical wall at *A*. The rod is held in equilibrium in a horizontal position by a light strut *CD* as shown in Figure 1. The rod and the strut lie in the same vertical plane, which is perpendicular to the wall. The end *C* of the strut is freely jointed to the wall at a point 0.5 m vertically below *A*. The end *D* is freely joined to the rod so that *AD* is 0.5 m.

(a) Find the thrust in *CD*.

(4)

(b) Find the magnitude and direction of the force exerted on the rod *AB* at *A*.

(7)

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Question 4 continued

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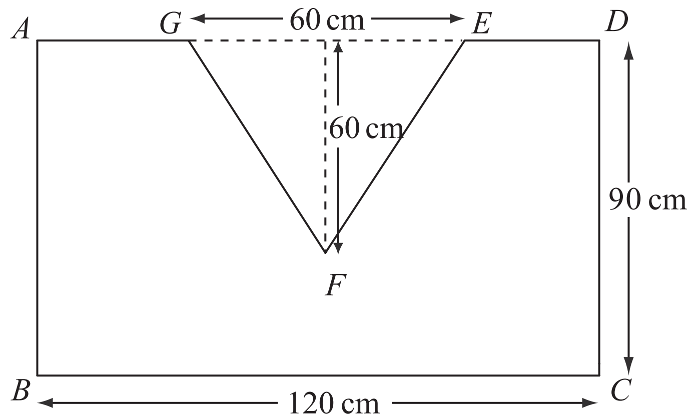

Figure 2

A shop sign *ABCDEFG* is modelled as a uniform lamina, as illustrated in Figure 2. *ABCD* is a rectangle with $BC = 120$ cm and $DC = 90$ cm. The shape *EFG* is an isosceles triangle with $EG = 60$ cm and height 60 cm. The mid-point of *AD* and the mid-point of *EG* coincide.

(a) Find the distance of the centre of mass of the sign from the side *AD*.

(5)

The sign is freely suspended from *A* and hangs at rest.

(b) Find the size of the angle between *AB* and the vertical.

(4)

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Question 5 continued

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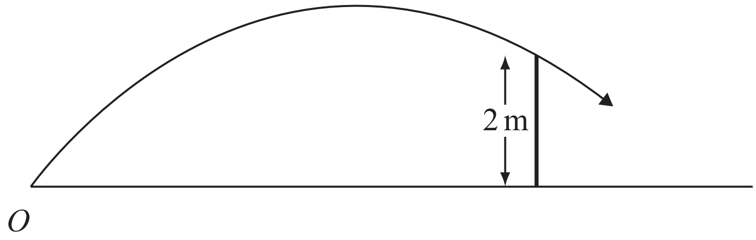

Figure 3

A child playing cricket on horizontal ground hits the ball towards a fence 10 m away. The ball moves in a vertical plane which is perpendicular to the fence. The ball just passes over the top of the fence, which is 2 m above the ground, as shown in Figure 3.

The ball is modelled as a particle projected with initial speed u m s^{-1} from point O on the ground at an angle α to the ground.

(a) By writing down expressions for the horizontal and vertical distances, from O of the ball t seconds after it was hit, show that

$$2 = 10\tan\alpha - \frac{50g}{u^2\cos^2\alpha}.$$

(6)

Given that $\alpha = 45°$,

(b) find the speed of the ball as it passes over the fence.

(6)

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Question 6 continued

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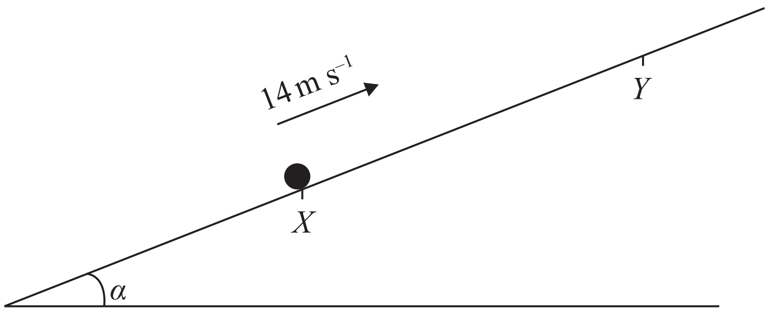

Figure 4

A particle P of mass 2 kg is projected up a rough plane with initial speed 14 m s^{-1}, from a point X on the plane, as shown in Figure 4. The particle moves up the plane along the line of greatest slope through X and comes to instantaneous rest at the point Y. The plane is inclined at an angle α to the horizontal, where $\tan \alpha = \frac{7}{24}$. The coefficient of friction between the particle and the plane is $\frac{1}{8}$.

(a) Use the work-energy principle to show that $XY = 25$ m.

(7)

After reaching Y, the particle P slides back down the plane.

(b) Find the speed of P as it passes through X.

(4)

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Question 7 continued

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8. Particles A, B and C of masses $4m$, $3m$ and m respectively, lie at rest in a straight line on a smooth horizontal plane with B between A and C. Particles A and B are projected towards each other with speeds u m s^{-1} and v m s^{-1} respectively, and collide directly.

As a result of the collision, A is brought to rest and B rebounds with speed kv m s^{-1}. The coefficient of restitution between A and B is $\frac{3}{4}$.

(a) Show that $u = 3v$.

(6)

(b) Find the value of k.

(2)

Immediately after the collision between A and B, particle C is projected with speed $2v$ m s^{-1} towards B so that B and C collide directly.

(c) Show that there is no further collision between A and B.

(4)

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Question 8 continued

Centre No.						Paper Reference	Surname	Initial(s)
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Paper Reference(s)

6678/01

Edexcel GCE

Mechanics M2

Advanced/Advanced Subsidiary

Friday 29 January 2010 – Morning

Time: 1 hour 30 minutes

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Question Number	Leave Blank
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Materials required for examination	**Items included with question papers**
Mathematical Formulae (Pink or Green)	Nil

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1. A particle P moves along the x-axis. At time t seconds the velocity of P is $v\,\text{m s}^{-1}$ in the positive x-direction, where $v = 3t^2 - 4t + 3$. When $t = 0$, P is at the origin O. Find the distance of P from O when P is moving with minimum velocity.

(8)

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2. Two particles, P, of mass $2m$, and Q, of mass m, are moving along the same straight line on a smooth horizontal plane. They are moving in opposite directions towards each other and collide. Immediately before the collision the speed of P is $2u$ and the speed of Q is u. The coefficient of restitution between the particles is e, where $e < 1$. Find, in terms of u and e,

(i) the speed of P immediately after the collision,

(ii) the speed of Q immediately after the collision.

(7)

Leave blank

3. A particle of mass 0.5 kg is projected vertically upwards from ground level with a speed of $20\,\mathrm{m\,s^{-1}}$. It comes to instantaneous rest at a height of 10 m above the ground. As the particle moves it is subject to air resistance of constant magnitude R newtons. Using the work-energy principle, or otherwise, find the value of R.

(6)

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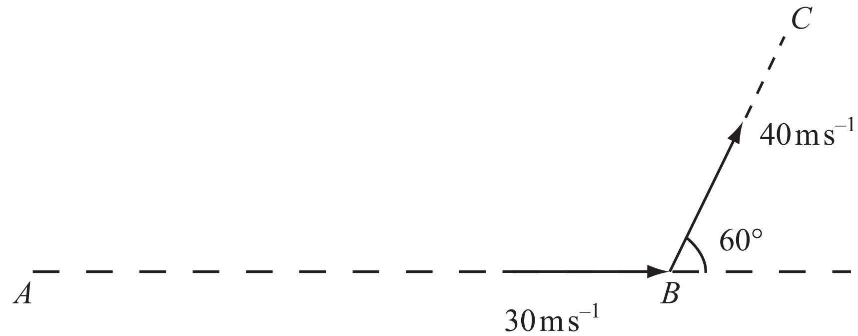

Figure 1

The points A, B and C lie in a horizontal plane. A batsman strikes a ball of mass 0.25 kg. Immediately before being struck, the ball is moving along the horizontal line AB with speed $30\,\text{m s}^{-1}$. Immediately after being struck, the ball moves along the horizontal line BC with speed $40\,\text{m s}^{-1}$. The line BC makes an angle of 60° with the original direction of motion AB, as shown in Figure 1.

Find, to 3 significant figures,

(i) the magnitude of the impulse given to the ball,

(ii) the size of the angle that the direction of this impulse makes with the original direction of motion AB.

(8)

M 3 5 1 0 2 A 0 8 2 8

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Question 4 continued

M 3 5 1 0 2 A 0 9 2 8

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5. A cyclist and her bicycle have a total mass of 70 kg. She cycles along a straight horizontal road with constant speed 3.5 m s^{-1}. She is working at a constant rate of 490 W.

(a) Find the magnitude of the resistance to motion.

(4)

The cyclist now cycles down a straight road which is inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{14}$, at a constant speed U m s^{-1}. The magnitude of the non-gravitational resistance to motion is modelled as $40U$ newtons. She is now working at a constant rate of 24 W.

(b) Find the value of U.

(7)

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Question 5 continued

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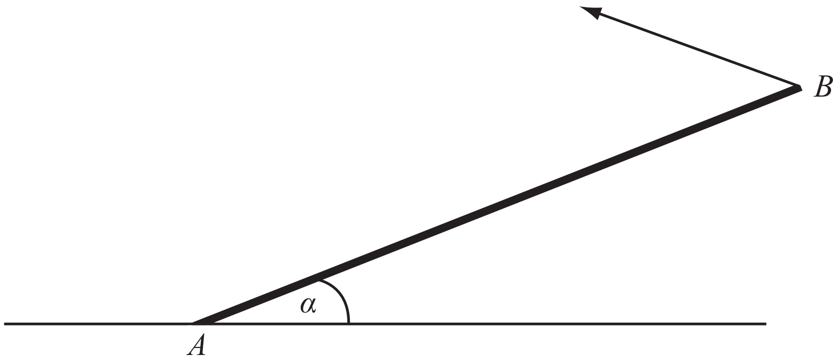

Figure 2

A uniform rod AB, of mass 20 kg and length 4 m, rests with one end A on rough horizontal ground. The rod is held in limiting equilibrium at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$, by a force acting at B, as shown in Figure 2. The line of action of this force lies in the vertical plane which contains the rod. The coefficient of friction between the ground and the rod is 0.5. Find the magnitude of the normal reaction of the ground on the rod at A.

(7)

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Question 6 continued

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7. [*The centre of mass of a semi-circular lamina of radius r is* $\frac{4r}{3\pi}$ *from the centre*]

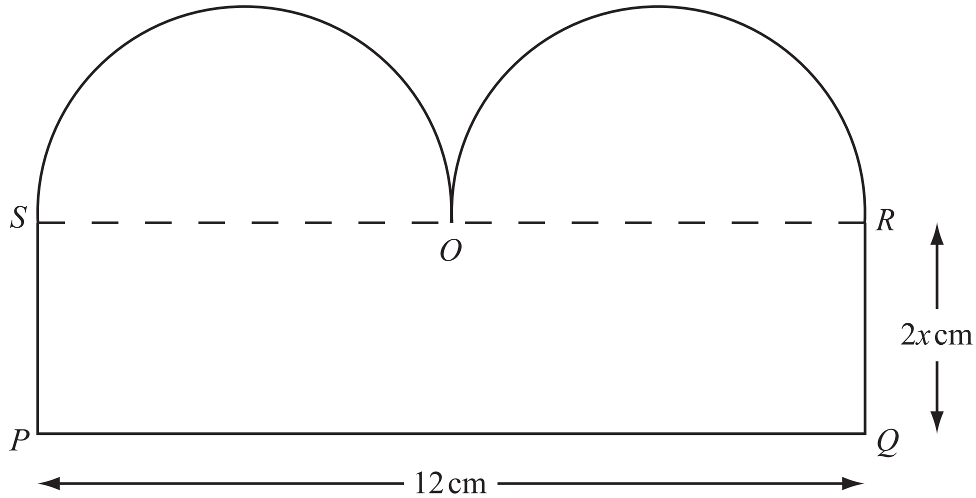

Figure 3

A template *T* consists of a uniform plane lamina *PQROS*, as shown in Figure 3. The lamina is bounded by two semicircles, with diameters *SO* and *OR*, and by the sides *SP*, *PQ* and *QR* of the rectangle *PQRS*. The point *O* is the mid-point of *SR*, *PQ* = 12 cm and *QR* = 2*x* cm.

(a) Show that the centre of mass of *T* is a distance $\frac{4|2x^2-3|}{8x+3\pi}$ cm from *SR*. **(7)**

The template *T* is freely suspended from the point *P* and hangs in equilibrium.

Given that $x = 2$ and that θ is the angle that *PQ* makes with the horizontal,

(b) show that $\tan\theta = \frac{48+9\pi}{22+6\pi}$. **(4)**

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Question 7 continued

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8. [*In this question* **i** *and* **j** *are unit vectors in a horizontal and upward vertical direction respectively*]

A particle P is projected from a fixed point O on horizontal ground with velocity $u(\mathbf{i} + c\mathbf{j})\,\text{m s}^{-1}$, where c and u are positive constants. The particle moves freely under gravity until it strikes the ground at A, where it immediately comes to rest. Relative to O, the position vector of a point on the path of P is $(x\mathbf{i} + y\mathbf{j})\,\text{m}$.

(a) Show that

$$y = cx - \frac{4.9x^2}{u^2}.$$

(5)

Given that $u = 7$, $OA = R\,\text{m}$ and the maximum vertical height of P above the ground is $H\,\text{m}$,

(b) using the result in part (a), or otherwise, find, in terms of c,

(i) R

(ii) H.

(6)

Given also that when P is at the point Q, the velocity of P is at right angles to its initial velocity,

(c) find, in terms of c, the value of x at Q.

(6)

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Question 8 continued

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Centre No.						Paper Reference	Surname	Initial(s)
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Paper Reference(s)

6678/01

Edexcel GCE

Mechanics M2

Advanced/Advanced Subsidiary

Friday 11 June 2010 – Morning

Time: 1 hour 30 minutes

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Question Number	Leave Blank
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Materials required for examination	**Items included with question papers**
Mathematical Formulae (Pink)	Nil

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1. A particle P moves on the x-axis. The acceleration of P at time t seconds, $t \geqslant 0$, is $(3t + 5)$ m s^{-2} in the positive x-direction. When $t = 0$, the velocity of P is 2 m s^{-1} in the positive x-direction. When $t = T$, the velocity of P is 6 m s^{-1} in the positive x-direction. Find the value of T.

(6)

Leave blank

2. A particle P of mass 0.6 kg is released from rest and slides down a line of greatest slope of a rough plane. The plane is inclined at 30° to the horizontal. When P has moved 12 m, its speed is 4 m s^{-1}. Given that friction is the only non-gravitational resistive force acting on P, find

(a) the work done against friction as the speed of P increases from 0 m s^{-1} to 4 m s^{-1},
(4)

(b) the coefficient of friction between the particle and the plane.
(4)

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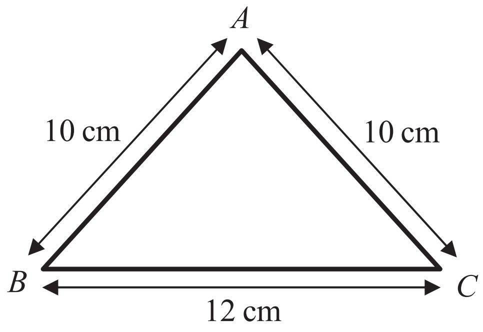

Figure 1

A triangular frame is formed by cutting a uniform rod into 3 pieces which are then joined to form a triangle *ABC*, where *AB* = *AC* = 10 cm and *BC* = 12 cm, as shown in Figure 1.

(a) Find the distance of the centre of mass of the frame from *BC*.

(5)

The frame has total mass *M*. A particle of mass *M* is attached to the frame at the mid-point of *BC*. The frame is then freely suspended from *B* and hangs in equilibrium.

(b) Find the size of the angle between *BC* and the vertical.

(4)

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Question 3 continued

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4. A car of mass 750 kg is moving up a straight road inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{15}$. The resistance to motion of the car from non-gravitational forces has constant magnitude R newtons. The power developed by the car's engine is 15 kW and the car is moving at a constant speed of 20 m s^{-1}.

(a) Show that $R = 260$.

(4)

The power developed by the car's engine is now increased to 18 kW. The magnitude of the resistance to motion from non-gravitational forces remains at 260 N. At the instant when the car is moving up the road at 20 m s^{-1} the car's acceleration is a m s^{-2}.

(b) Find the value of a.

(4)

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Question 4 continued

Leave blank

5. [*In this question* **i** *and* **j** *are perpendicular unit vectors in a horizontal plane.*]

A ball of mass 0.5 kg is moving with velocity $(10\mathbf{i} + 24\mathbf{j})\ \text{m s}^{-1}$ when it is struck by a bat. Immediately after the impact the ball is moving with velocity $20\mathbf{i}\ \text{m s}^{-1}$.

Find

(a) the magnitude of the impulse of the bat on the ball,
(4)

(b) the size of the angle between the vector **i** and the impulse exerted by the bat on the ball,
(2)

(c) the kinetic energy lost by the ball in the impact.
(3)

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Question 5 continued

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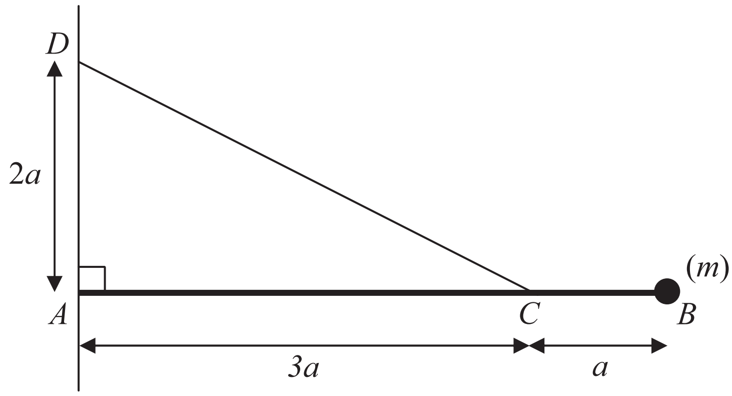

Figure 2

Figure 2 shows a uniform rod AB of mass m and length $4a$. The end A of the rod is freely hinged to a point on a vertical wall. A particle of mass m is attached to the rod at B. One end of a light inextensible string is attached to the rod at C, where $AC = 3a$. The other end of the string is attached to the wall at D, where $AD = 2a$ and D is vertically above A. The rod rests horizontally in equilibrium in a vertical plane perpendicular to the wall and the tension in the string is T.

(a) Show that $T = mg\sqrt{13}$.

(5)

The particle of mass m at B is removed from the rod and replaced by a particle of mass M which is attached to the rod at B. The string breaks if the tension exceeds $2mg\sqrt{13}$. Given that the string does not break,

(b) show that $M \leqslant \frac{5}{2}m$.

(3)

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Question 6 continued

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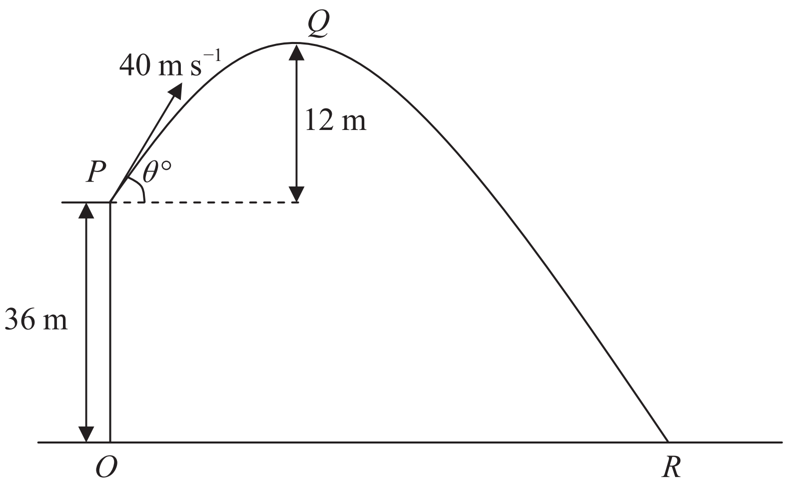

Figure 3

A ball is projected with speed 40 m s^{-1} from a point P on a cliff above horizontal ground. The point O on the ground is vertically below P and OP is 36 m. The ball is projected at an angle $\theta°$ to the horizontal. The point Q is the highest point of the path of the ball and is 12 m above the level of P. The ball moves freely under gravity and hits the ground at the point R, as shown in Figure 3. Find

(a) the value of θ,

(3)

(b) the distance OR,

(6)

(c) the speed of the ball as it hits the ground at R.

(3)

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Question 7 continued

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8. A small ball A of mass $3m$ is moving with speed u in a straight line on a smooth horizontal table. The ball collides directly with another small ball B of mass m moving with speed u towards A along the same straight line. The coefficient of restitution between A and B is $\frac{1}{2}$. The balls have the same radius and can be modelled as particles.

(a) Find

(i) the speed of A immediately after the collision,

(ii) the speed of B immediately after the collision.

(7)

After the collision B hits a smooth vertical wall which is perpendicular to the direction of motion of B. The coefficient of restitution between B and the wall is $\frac{2}{5}$.

(b) Find the speed of B immediately after hitting the wall.

(2)

The first collision between A and B occurred at a distance $4a$ from the wall. The balls collide again T seconds after the first collision.

(c) Show that $T = \dfrac{112a}{15u}$.

(6)

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Question 8 continued

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January 2011

Centre No.						Paper Reference							Surname	Initial(s)
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Paper Reference(s)

6678/01

Edexcel GCE

Mechanics M2

Advanced/Advanced Subsidiary

Friday 28 January 2011 – Morning

Time: 1 hour 30 minutes

Materials required for examination	Items included with question papers
Mathematical Formulae (Pink)	Nil

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1. A cyclist starts from rest and moves along a straight horizontal road. The combined mass of the cyclist and his cycle is 120 kg. The resistance to motion is modelled as a constant force of magnitude 32 N. The rate at which the cyclist works is 384 W. The cyclist accelerates until he reaches a constant speed of v m s^{-1}.

Find

(a) the value of v,

(3)

(b) the acceleration of the cyclist at the instant when the speed is 9 m s^{-1}.

(3)

Leave blank

2. A particle of mass 2 kg is moving with velocity $(5\mathbf{i}+\mathbf{j})$ m s^{-1} when it receives an impulse of $(-6\mathbf{i}+8\mathbf{j})$ N s. Find the kinetic energy of the particle immediately after receiving the impulse.

(5)

Leave blank

3. A particle moves along the x-axis. At time $t = 0$ the particle passes through the origin with speed 8 m s^{-1} in the positive x-direction. The acceleration of the particle at time t seconds, $t \geqslant 0$, is $(4t^3 - 12t)$ m s^{-2} in the positive x-direction.

Find

(a) the velocity of the particle at time t seconds,

(3)

(b) the displacement of the particle from the origin at time t seconds,

(2)

(c) the values of t at which the particle is instantaneously at rest.

(3)

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Question 3 continued

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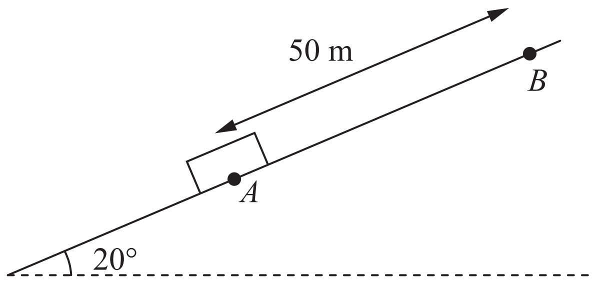

Figure 1

A box of mass 30 kg is held at rest at point A on a rough inclined plane. The plane is inclined at 20° to the horizontal. Point B is 50 m from A up a line of greatest slope of the plane, as shown in Figure 1. The box is dragged from A to B by a force acting parallel to AB and then held at rest at B. The coefficient of friction between the box and the plane is $\frac{1}{4}$. Friction is the only non-gravitational resistive force acting on the box. Modelling the box as a particle,

(a) find the work done in dragging the box from A to B.

(6)

The box is released from rest at the point B and slides down the slope. Using the work-energy principle, or otherwise,

(b) find the speed of the box as it reaches A.

(5)

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Question 4 continued

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Question 4 continued

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Question 4 continued

(Total 11 marks)

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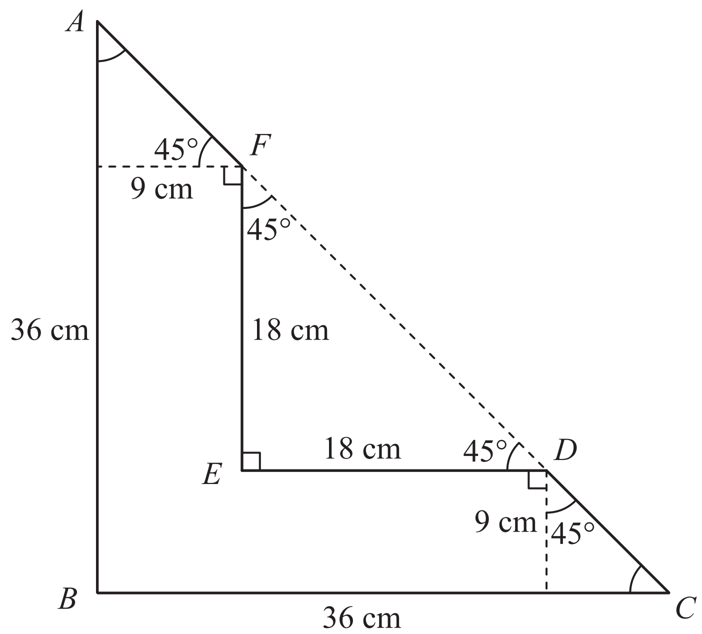

Figure 2

The uniform L-shaped lamina *ABCDEF*, shown in Figure 2, has sides *AB* and *FE* parallel, and sides *BC* and *ED* parallel. The pairs of parallel sides are 9 cm apart. The points *A*, *F*, *D* and *C* lie on a straight line.

$AB = BC = 36$ cm, $FE = ED = 18$ cm. $\angle ABC = \angle FED = 90°$, and
$\angle BCD = \angle EDF = \angle EFD = \angle BAC = 45°$.

(a) Find the distance of the centre of mass of the lamina from

(i) side *AB*,

(ii) side *BC*.

(7)

The lamina is freely suspended from *A* and hangs in equilibrium.

(b) Find, to the nearest degree, the size of the angle between *AB* and the vertical.

(3)

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Question 5 continued

N35408A01528

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6. [*In this question, the unit vectors* **i** *and* **j** *are in a vertical plane,* **i** *being horizontal and* **j** *being vertically upwards.*]

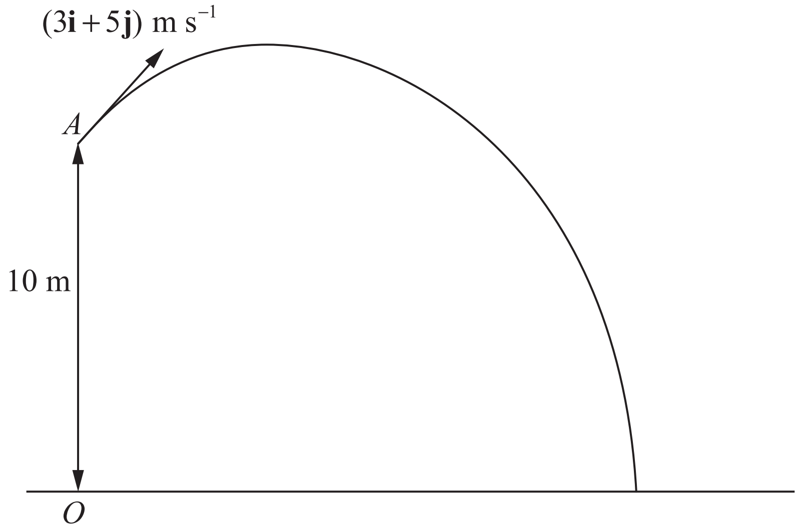

Figure 3

At time $t = 0$, a particle P is projected from the point A which has position vector 10**j** metres with respect to a fixed origin O at ground level. The ground is horizontal. The velocity of projection of P is $(3\mathbf{i} + 5\mathbf{j})$ m s^{-1}, as shown in Figure 3. The particle moves freely under gravity and reaches the ground after T seconds.

(a) For $0 \leqslant t \leqslant T$, show that, with respect to O, the position vector, **r** metres, of P at time t seconds is given by

$$\mathbf{r} = 3t\mathbf{i} + (10 + 5t - 4.9t^2)\mathbf{j}$$

(3)

(b) Find the value of T.

(3)

(c) Find the velocity of P at time t seconds $(0 \leqslant t \leqslant T)$.

(2)

When P is at the point B, the direction of motion of P is 45° below the horizontal.

(d) Find the time taken for P to move from A to B.

(2)

(e) Find the speed of P as it passes through B.

(2)

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Question 6 continued

N35408A01928

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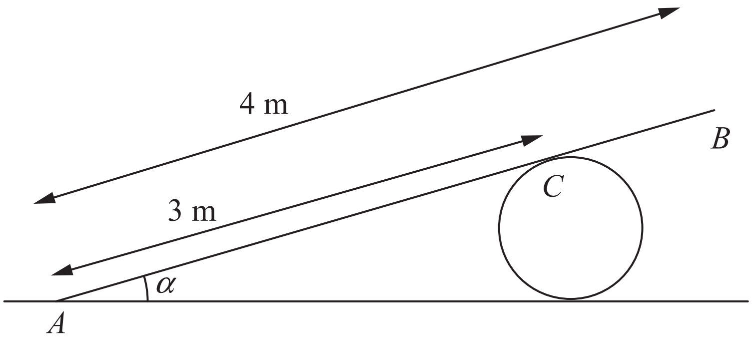

Figure 4

A uniform plank *AB*, of weight 100 N and length 4 m, rests in equilibrium with the end *A* on rough horizontal ground. The plank rests on a smooth cylindrical drum. The drum is fixed to the ground and cannot move. The point of contact between the plank and the drum is *C*, where $AC = 3$ m, as shown in Figure 4. The plank is resting in a vertical plane which is perpendicular to the axis of the drum, at an angle α to the horizontal, where $\sin\alpha = \frac{1}{3}$. The coefficient of friction between the plank and the ground is μ. Modelling the plank as a rod, find the least possible value of μ.

(10)

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Question 7 continued

N35408A02328

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8. A particle P of mass m kg is moving with speed 6 m s^{-1} in a straight line on a smooth horizontal floor. The particle strikes a fixed smooth vertical wall at right angles and rebounds. The kinetic energy lost in the impact is 64 J. The coefficient of restitution between P and the wall is $\frac{1}{3}$.

(a) Show that $m = 4$.

(6)

After rebounding from the wall, P collides directly with a particle Q which is moving towards P with speed 3 m s^{-1}. The mass of Q is 2 kg and the coefficient of restitution between P and Q is $\frac{1}{3}$.

(b) Show that there will be a second collision between P and the wall.

(7)

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Question 8 continued

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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

Monday 13 June 2011 – Morning

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
2	
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Total	

Materials required for examination	Items included with question papers
Mathematical Formulae (Pink)	Nil

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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 paper is 75.
There are 28 pages in this question paper. Any blank pages are indicated.

Advice to Candidates

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Answers without working may not gain full credit.

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1. A car of mass 1000 kg moves with constant speed V m s^{-1} up a straight road inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{30}$. The engine of the car is working at a rate of 12 kW. The resistance to motion from non-gravitational forces has magnitude 500 N.

Find the value of V.

(5)

Leave blank

2. A particle P of mass m is moving in a straight line on a smooth horizontal surface with speed $4u$. The particle P collides directly with a particle Q of mass $3m$ which is at rest on the surface. The coefficient of restitution between P and Q is e. The direction of motion of P is reversed by the collision.

Show that $e > \frac{1}{3}$.

(8)

Leave blank

3. A ball of mass 0.5 kg is moving with velocity 12**i** m s^{-1} when it is struck by a bat. The impulse received by the ball is ($-4\mathbf{i}+7\mathbf{j}$) N s. By modelling the ball as a particle, find

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

(4)

(b) the angle, in degrees, between the velocity of the ball immediately after the impact and the vector **i**,

(2)

(c) the kinetic energy gained by the ball as a result of the impact.

(2)

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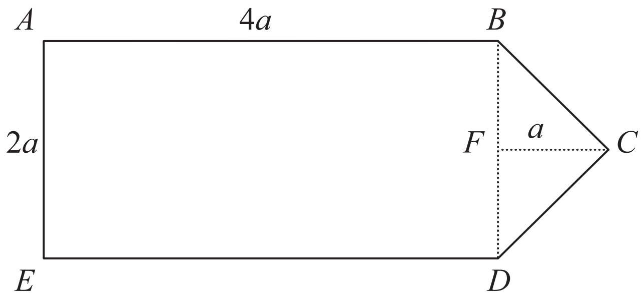

Figure 1

Figure 1 shows a uniform lamina $ABCDE$ such that $ABDE$ is a rectangle, $BC = CD$, $AB = 4a$ and $AE = 2a$. The point F is the midpoint of BD and $FC = a$.

(a) Find, in terms of a, the distance of the centre of mass of the lamina from AE.

(4)

The lamina is freely suspended from A and hangs in equilibrium.

(b) Find the angle between AB and the downward vertical.

(3)

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Question 4 continued

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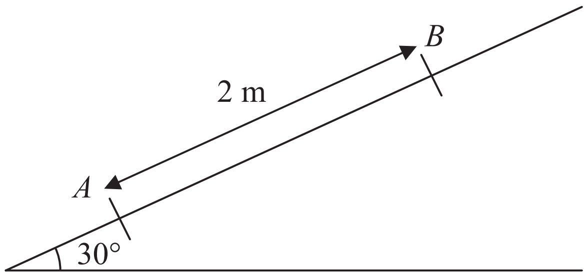

Figure 2

A particle P of mass 0.5 kg is projected from a point A up a line of greatest slope AB of a fixed plane. The plane is inclined at 30° to the horizontal and AB = 2 m with B above A, as shown in Figure 2. The particle P passes through B with speed 5 m s^{-1}. The plane is smooth from A to B.

(a) Find the speed of projection.

(4)

The particle P comes to instantaneous rest at the point C on the plane, where C is above B and $BC = 1.5$ m. From B to C the plane is rough and the coefficient of friction between P and the plane is μ.

By using the work-energy principle,

(b) find the value of μ.

(6)

Leave blank

Question 5 continued

Leave blank

6. A particle P moves on the x-axis. The acceleration of P at time t seconds is $(t-4)$ m s^{-2} in the positive x-direction. The velocity of P at time t seconds is v m s^{-1}. When $t = 0$, $v = 6$.

Find

(a) v in terms of t,

(4)

(b) the values of t when P is instantaneously at rest,

(3)

(c) the distance between the two points at which P is instantaneously at rest.

(4)

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Question 6 continued

P 3 8 1 6 2 A 0 1 7 2 8

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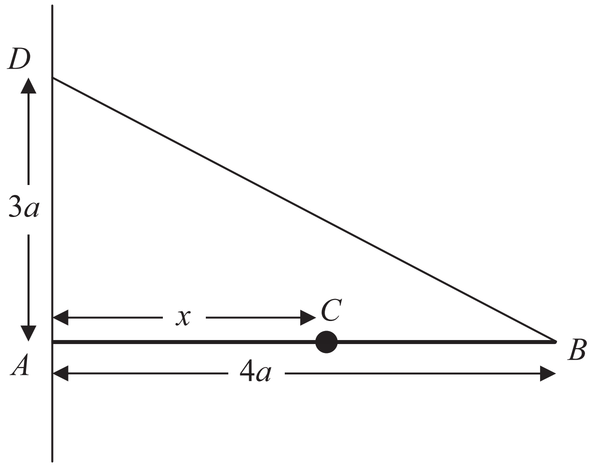

Figure 3

A uniform rod AB, of mass $3m$ and length $4a$, is held in a horizontal position with the end A against a rough vertical wall. One end of a light inextensible string BD is attached to the rod at B and the other end of the string is attached to the wall at the point D vertically above A, where $AD = 3a$. A particle of mass $3m$ is attached to the rod at C, where $AC = x$. The rod is in equilibrium in a vertical plane perpendicular to the wall as shown in Figure 3. The tension in the string is $\frac{25}{4}mg$.

Show that

(a) $x = 3a$,

(5)

(b) the horizontal component of the force exerted by the wall on the rod has magnitude $5mg$.

(3)

The coefficient of friction between the wall and the rod is μ. Given that the rod is about to slip,

(c) find the value of μ.

(5)

P 3 8 1 6 2 A 0 2 0 2 8

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Question 7 continued

P 3 8 1 6 2 A 0 2 1 2 8

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8. A particle is projected from a point O with speed u at an angle of elevation α above the horizontal and moves freely under gravity. When the particle has moved a horizontal distance x, its height above O is y.

(a) Show that

$$y = x\tan\alpha - \frac{gx^2}{2u^2\cos^2\alpha}$$

(4)

A girl throws a ball from a point A at the top of a cliff. The point A is 8 m above a horizontal beach. The ball is projected with speed 7 m s^{-1} at an angle of elevation of 45°. By modelling the ball as a particle moving freely under gravity,

(b) find the horizontal distance of the ball from A when the ball is 1 m above the beach.

(5)

A boy is standing on the beach at the point B vertically below A. He starts to run in a straight line with speed $v\text{ m s}^{-1}$, leaving B 0.4 seconds after the ball is thrown.

He catches the ball when it is 1 m above the beach.

(c) Find the value of v.

(4)

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Question 8 continued

P 3 8 1 6 2 A 0 2 5 2 8

Turn over

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

Friday 27 January 2012 – Morning

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
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Materials required for examination	**Items included with question papers**
Mathematical Formulae (Pink)	Nil

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There are 28 pages in this question paper. Any blank pages are indicated.

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Turn over

PEARSON

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1. A tennis ball of mass 0.1 kg is hit by a racquet. Immediately before being hit, the ball has velocity $30\mathbf{i}\ \text{m s}^{-1}$. The racquet exerts an impulse of $(-2\mathbf{i} - 4\mathbf{j})$ N s on the ball. By modelling the ball as a particle, find the velocity of the ball immediately after being hit.
(4)

Leave blank

2. A particle P is moving in a plane. At time t seconds, P is moving with velocity $\mathbf{v}$ m s^{-1}, where $\mathbf{v} = 2t\mathbf{i} - 3t^2\mathbf{j}$.

Find

(a) the speed of P when $t = 4$

(2)

(b) the acceleration of P when $t = 4$

(3)

Given that P is at the point with position vector $(-4\mathbf{i} + \mathbf{j})$ m when $t = 1$,

(c) find the position vector of P when $t = 4$

(5)

Leave blank

3. A cyclist and her cycle have a combined mass of 75 kg. The cyclist is cycling up a straight road inclined at 5° to the horizontal. The resistance to the motion of the cyclist from non-gravitational forces is modelled as a constant force of magnitude 20 N. At the instant when the cyclist has a speed of 12 m s^{-1}, she is decelerating at 0.2 m s^{-2}.

(a) Find the rate at which the cyclist is working at this instant.

(5)

When the cyclist passes the point *A* her speed is 8 m s^{-1}. At *A* she stops working but does not apply the brakes. She comes to rest at the point *B*.
The resistance to motion from non-gravitational forces is again modelled as a constant force of magnitude 20 N.

(b) Use the work-energy principle to find the distance *AB*.

(5)

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Question 3 continued

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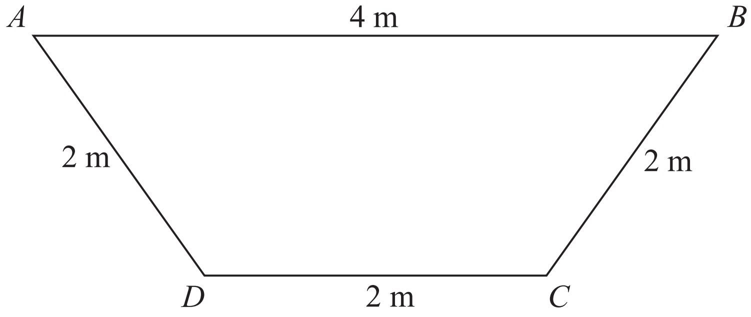

Figure 1

The trapezium $ABCD$ is a uniform lamina with $AB = 4$ m and $BC = CD = DA = 2$ m, as shown in Figure 1.

(a) Show that the centre of mass of the lamina is $\frac{4\sqrt{3}}{9}$ m from AB.

(5)

The lamina is freely suspended from D and hangs in equilibrium.

(b) Find the angle between DC and the vertical through D.

(5)

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Question 4 continued

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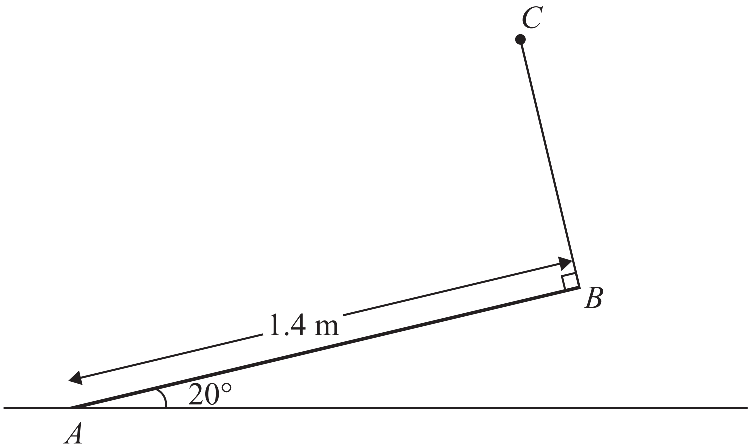

Figure 2

A uniform rod *AB* has mass 4 kg and length 1.4 m. The end *A* is resting on rough horizontal ground. A light string *BC* has one end attached to *B* and the other end attached to a fixed point *C*. The string is perpendicular to the rod and lies in the same vertical plane as the rod. The rod is in equilibrium, inclined at 20° to the ground, as shown in Figure 2.

(a) Find the tension in the string.

(4)

Given that the rod is about to slip,

(b) find the coefficient of friction between the rod and the ground.

(7)

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Question 5 continued

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6. Three identical particles, A, B and C, lie at rest in a straight line on a smooth horizontal table with B between A and C. The mass of each particle is m. Particle A is projected towards B with speed u and collides directly with B. The coefficient of restitution between each pair of particles is $\frac{2}{3}$.

(a) Find, in terms of u,

(i) the speed of A after this collision,

(ii) the speed of B after this collision.

(7)

(b) Show that the kinetic energy lost in this collision is $\frac{5}{36}mu^2$

(4)

After the collision between A and B, particle B collides directly with C.

(c) Find, in terms of u, the speed of C immediately after this collision between B and C.

(4)

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Question 6 continued

P 4 0 0 9 5 A 0 2 1 2 8

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7. [*In this question, the unit vectors* **i** *and* **j** *are horizontal and vertical respectively*.]

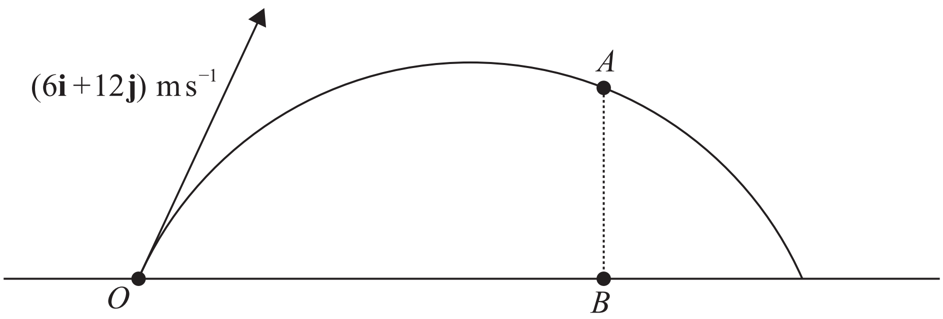

Figure 3

The point O is a fixed point on a horizontal plane. A ball is projected from O with velocity $(6\mathbf{i} + 12\mathbf{j})$ m s^{-1}, and passes through the point A at time t seconds after projection. The point B is on the horizontal plane vertically below A, as shown in Figure 3. It is given that $OB = 2AB$.

Find

(a) the value of t,

(7)

(b) the speed, V m s^{-1}, of the ball at the instant when it passes through A.

(5)

At another point C on the path the speed of the ball is also V m s^{-1}.

(c) Find the time taken for the ball to travel from O to C.

(3)

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Question 7 continued

P 4 0 0 9 5 A 0 2 5 2 8

Turn over

June 2012

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

Thursday 31 May 2012 – Morning

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
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Materials required for examination	**Items included with question papers**
Mathematical Formulae (Pink)	Nil

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PEARSON

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1. [*In this question* **i** *and* **j** *are perpendicular unit vectors in a horizontal plane.*]

A particle P moves in such a way that its velocity $\mathbf{v}$ m s^{-1} at time t seconds is given by

$$\mathbf{v} = (3t^2 - 1)\mathbf{i} + (4t - t^2)\mathbf{j}$$

(a) Find the magnitude of the acceleration of P when $t = 1$

(5)

Given that, when $t = 0$, the position vector of P is $\mathbf{i}$ metres,

(b) find the position vector of P when $t = 3$

(5)

Leave blank

2. A particle P of mass $3m$ is moving with speed $2u$ in a straight line on a smooth horizontal plane. The particle P collides directly with a particle Q of mass $4m$ moving on the plane with speed u in the opposite direction to P. The coefficient of restitution between P and Q is e.

(a) Find the speed of Q immediately after the collision.

(6)

Given that the direction of motion of P is reversed by the collision,

(b) find the range of possible values of e.

(5)

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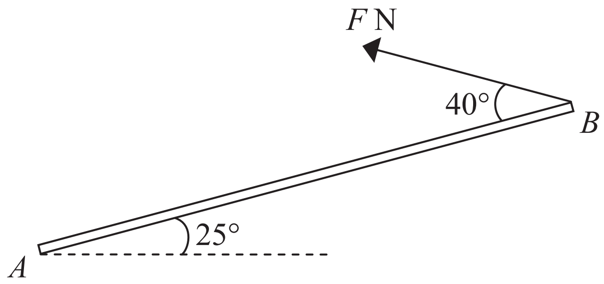

Figure 1

A uniform rod *AB*, of mass 5 kg and length 4 m, has its end *A* smoothly hinged at a fixed point. The rod is held in equilibrium at an angle of 25° above the horizontal by a force of magnitude *F* newtons applied to its end *B*. The force acts in the vertical plane containing the rod and in a direction which makes an angle of 40° with the rod, as shown in Figure 1.

(a) Find the value of *F*.

(4)

(b) Find the magnitude and direction of the vertical component of the force acting on the rod at *A*.

(4)

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Question 3 continued

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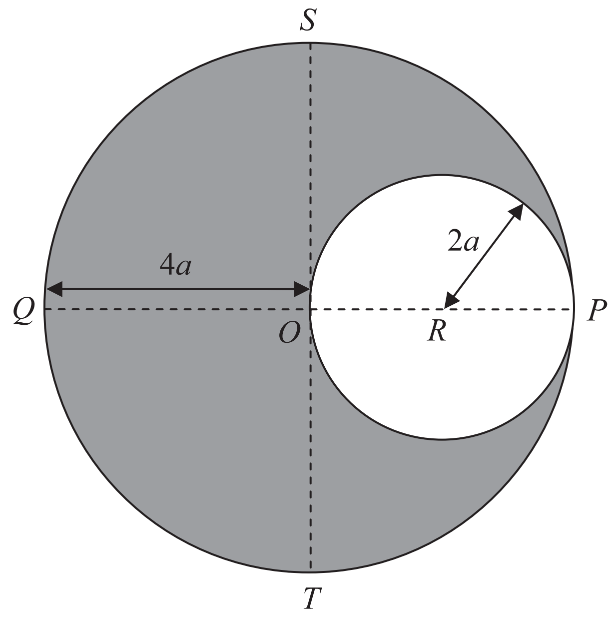

Figure 2

A uniform circular disc has centre O and radius $4a$. The lines PQ and ST are perpendicular diameters of the disc. A circular hole of radius $2a$ is made in the disc, with the centre of the hole at the point R on OP where $OR = 2a$, to form the lamina L, shown shaded in Figure 2.

(a) Show that the distance of the centre of mass of L from P is $\dfrac{14a}{3}$.

(4)

The mass of L is m and a particle of mass km is now fixed to L at the point P. The system is now suspended from the point S and hangs freely in equilibrium. The diameter ST makes an angle α with the downward vertical through S, where $\tan\alpha = \dfrac{5}{6}$.

(b) Find the value of k.

(5)

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Question 4 continued

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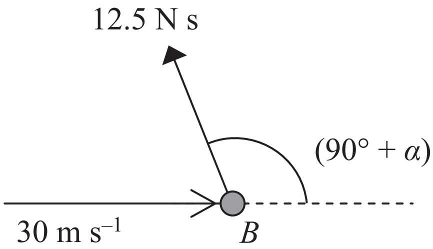

Figure 3

A small ball B of mass 0.25 kg is moving in a straight line with speed 30 m s^{-1} on a smooth horizontal plane when it is given an impulse. The impulse has magnitude 12.5 N s and is applied in a horizontal direction making an angle of $(90° + \alpha)$, where $\tan\alpha = \frac{3}{4}$, with the initial direction of motion of the ball, as shown in Figure 3.

(i) Find the speed of B immediately after the impulse is applied.

(ii) Find the direction of motion of B immediately after the impulse is applied.

(6)

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Question 5 continued

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6. A car of mass 1200 kg pulls a trailer of mass 400 kg up a straight road which is inclined to the horizontal at an angle α, where $\sin \alpha = \frac{1}{14}$. The trailer is attached to the car by a light inextensible towbar which is parallel to the road. The car's engine works at a constant rate of 60 kW. The non-gravitational resistances to motion are constant and of magnitude 1000 N on the car and 200 N on the trailer.

At a given instant, the car is moving at 10 m s^{-1}. Find

(a) the acceleration of the car at this instant,

(5)

(b) the tension in the towbar at this instant.

(4)

The towbar breaks when the car is moving at 12 m s^{-1} .

(c) Find, using the work-energy principle, the further distance that the trailer travels before coming instantaneously to rest.

(5)

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Question 6 continued

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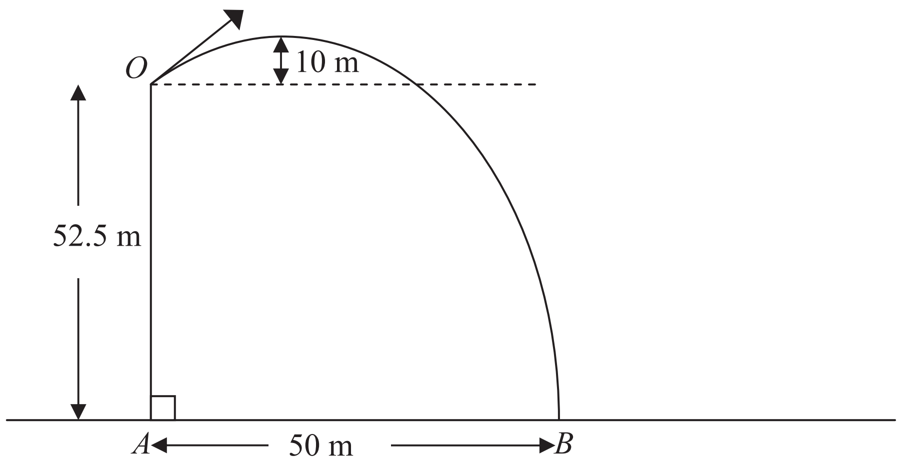

Figure 4

A small stone is projected from a point O at the top of a vertical cliff OA. The point O is 52.5 m above the sea. The stone rises to a maximum height of 10 m above the level of O before hitting the sea at the point B, where $AB = 50$ m, as shown in Figure 4. The stone is modelled as a particle moving freely under gravity.

(a) Show that the vertical component of the velocity of projection of the stone is 14 m s^{-1}.
(3)

(b) Find the speed of projection.
(9)

(c) Find the time after projection when the stone is moving parallel to OB.
(5)

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Question 7 continued

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

Friday 25 January 2013 – Afternoon

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
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Materials required for examination	Items included with question papers
Mathematical Formulae (Pink)	Nil

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Instructions to Candidates

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Information for Candidates

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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.
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Answers without working may not gain full credit.

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PEARSON

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1. Two uniform rods AB and BC are rigidly joined at B so that $\angle ABC = 90°$. Rod AB has length 0.5 m and mass 2 kg. Rod BC has length 2 m and mass 3 kg. The centre of mass of the framework of the two rods is at G.

(a) Find the distance of G from BC.

(2)

The distance of G from AB is 0.6 m.
The framework is suspended from A and hangs freely in equilibrium.

(b) Find the angle between AB and the downward vertical at A.

(3)

Leave blank

2. A lorry of mass 1800 kg travels along a straight horizontal road. The lorry's engine is working at a constant rate of 30 kW. When the lorry's speed is 20 m s^{-1}, its acceleration is 0.4 m s^{-2}. The magnitude of the resistance to the motion of the lorry is R newtons.

(a) Find the value of R.

(4)

The lorry now travels up a straight road which is inclined at an angle α to the horizontal, where $\sin \alpha = \frac{1}{12}$. The magnitude of the non-gravitational resistance to motion is R newtons. The lorry travels at a constant speed of 20 m s^{-1}.

(b) Find the new rate of working of the lorry's engine.

(5)

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Question 2 continued

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3.

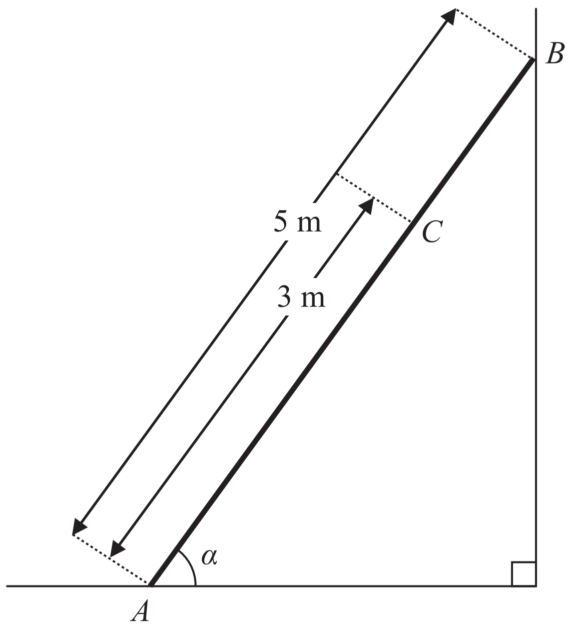

Figure 1

A ladder, of length 5 m and mass 18 kg, has one end A resting on rough horizontal ground and its other end B resting against a smooth vertical wall. The ladder lies in a vertical plane perpendicular to the wall and makes an angle α with the horizontal ground, where $\tan\alpha = \frac{4}{3}$, as shown in Figure 1. The coefficient of friction between the ladder and the ground is μ. A woman of mass 60 kg stands on the ladder at the point C, where $AC = 3$ m. The ladder is on the point of slipping. The ladder is modelled as a uniform rod and the woman as a particle.

Find the value of μ.

(9)

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Question 3 continued

P 4 1 4 8 0 A 0 9 2 8

Turn over

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4. At time t seconds the velocity of a particle P is $[(4t - 5)\mathbf{i} + 3\mathbf{j}]$ m s^{-1}. When $t = 0$, the position vector of P is $(2\mathbf{i} + 5\mathbf{j})$ m, relative to a fixed origin O.

(a) Find the value of t when the velocity of P is parallel to the vector $\mathbf{j}$.

(1)

(b) Find an expression for the position vector of P at time t seconds.

(4)

A second particle Q moves with constant velocity $(-2\mathbf{i} + c\mathbf{j})$ m s^{-1}. When $t = 0$, the position vector of Q is $(11\mathbf{i} + 2\mathbf{j})$ m. The particles P and Q collide at the point with position vector $(d\mathbf{i} + 14\mathbf{j})$ m.

(c) Find

(i) the value of c,

(ii) the value of d.

(5)

Leave blank

Question 4 continued

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5. The point A lies on a rough plane inclined at an angle θ to the horizontal, where $\sin\theta = \frac{24}{25}$. A particle P is projected from A, up a line of greatest slope of the plane, with speed U m s^{-1}. The mass of P is 2 kg and the coefficient of friction between P and the plane is $\frac{5}{12}$. The particle comes to instantaneous rest at the point B on the plane, where $AB = 1.5$ m. It then moves back down the plane to A.

(a) Find the work done against friction as P moves from A to B.
(4)

(b) Use the work-energy principle to find the value of U.
(4)

(c) Find the speed of P when it returns to A.
(3)

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Question 5 continued

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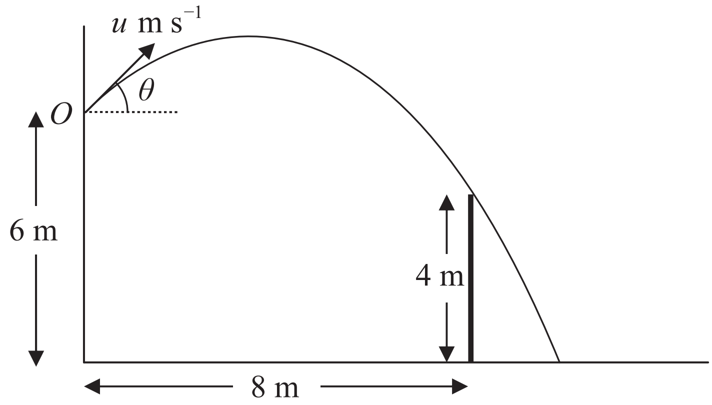

Figure 2

A ball is thrown from a point O, which is 6 m above horizontal ground. The ball is projected with speed u m s^{-1} at an angle θ above the horizontal. There is a thin vertical post which is 4 m high and 8 m horizontally away from the vertical through O, as shown in Figure 2. The ball passes just above the top of the post 2 s after projection. The ball is modelled as a particle.

(a) Show that $\tan \theta = 2.2$

(5)

(b) Find the value of u.

(2)

The ball hits the ground T seconds after projection.

(c) Find the value of T.

(3)

Immediately before the ball hits the ground the direction of motion of the ball makes an angle α with the horizontal.

(d) Find α.

(5)

Leave blank

Question 6 continued

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7. A particle A of mass m is moving with speed u on a smooth horizontal floor when it collides directly with another particle B, of mass $3m$, which is at rest on the floor. The coefficient of restitution between the particles is e. The direction of motion of A is reversed by the collision.

(a) Find, in terms of e and u,

(i) the speed of A immediately after the collision,

(ii) the speed of B immediately after the collision.

(7)

After being struck by A the particle B collides directly with another particle C, of mass $4m$, which is at rest on the floor. The coefficient of restitution between B and C is $2e$. Given that the direction of motion of B is reversed by this collision,

(b) find the range of possible values of e,

(6)

(c) determine whether there will be a second collision between A and B.

(3)

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Question 7 continued

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

Paper Reference(s)

6678/01R

Edexcel GCE

Mechanics M2

Advanced/Advanced Subsidiary

Thursday 6 June 2013 – Morning

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
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Materials required for examination	**Items included with question papers**
Mathematical Formulae (Pink)	Nil

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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

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Answers without working may not gain full credit.

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PEARSON

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1. A caravan of mass 600 kg is towed by a car of mass 900 kg along a straight horizontal road. The towbar joining the car to the caravan is modelled as a light rod parallel to the road. The total resistance to motion of the car is modelled as having magnitude 300 N. The total resistance to motion of the caravan is modelled as having magnitude 150 N. At a given instant the car and the caravan are moving with speed 20 m s^{-1} and acceleration 0.2 m s^{-2}.

(a) Find the power being developed by the car's engine at this instant.

(5)

(b) Find the tension in the towbar at this instant.

(2)

Leave blank

2. A ball of mass 0.2 kg is projected vertically upwards from a point O with speed 20 m s^{-1}. The non-gravitational resistance acting on the ball is modelled as a force of constant magnitude 1.24 N and the ball is modelled as a particle. Find, using the work-energy principle, the speed of the ball when it first reaches the point which is 8 m vertically above O.

(6)

Leave blank

3. A particle P moves along a straight line in such a way that at time t seconds its velocity v m s^{-1} is given by

$$v = \frac{1}{2}t^2 - 3t + 4$$

Find

(a) the times when P is at rest,

(4)

(b) the total distance travelled by P between $t = 0$ and $t = 4$.

(5)

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Question 3 continued

P 4 2 8 3 0 A 0 7 2 8

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4. A rough circular cylinder of radius $4a$ is fixed to a rough horizontal plane with its axis horizontal. A uniform rod AB, of weight W and length $6a\sqrt{3}$, rests with its lower end A on the plane and a point C of the rod against the cylinder. The vertical plane through the rod is perpendicular to the axis of the cylinder. The rod is inclined at 60° to the horizontal, as shown in Figure 1.

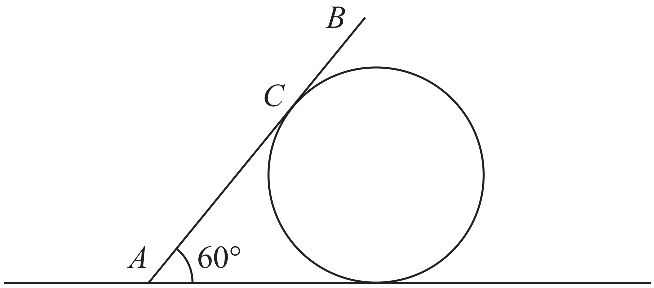

Figure 1

(a) Show that $AC = 4a\sqrt{3}$

(2)

The coefficient of friction between the rod and the cylinder is $\frac{\sqrt{3}}{3}$ and the coefficient of friction between the rod and the plane is μ. Given that friction is limiting at both A and C,

(b) find the value of μ.

(9)

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Question 4 continued

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5. Two particles P and Q, of masses $2m$ and m respectively, are on a smooth horizontal table. Particle Q is at rest and particle P collides directly with it when moving with speed u. After the collision the total kinetic energy of the two particles is $\frac{3}{4}mu^2$. Find

(a) the speed of Q immediately after the collision,
(10)

(b) the coefficient of restitution between the particles.
(3)

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Question 5 continued

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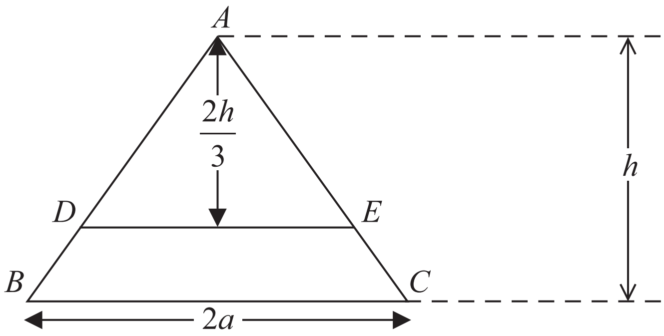

Figure 2

A uniform triangular lamina ABC of mass M is such that $AB = AC$, $BC = 2a$ and the distance of A from BC is h. A line, parallel to BC and at a distance $\frac{2h}{3}$ from A, cuts AB at D and cuts AC at E, as shown in Figure 2.

It is given that the mass of the trapezium $BCED$ is $\frac{5M}{9}$.

(a) Show that the centre of mass of the trapezium $BCED$ is $\frac{7h}{45}$ from BC.

(5)

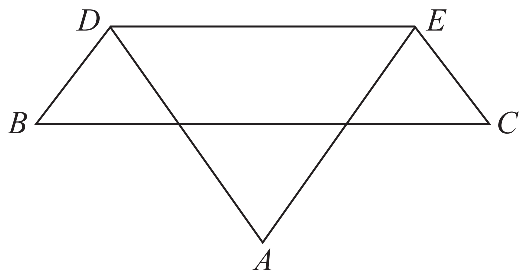

Figure 3

The portion ADE of the lamina is folded through 180° about DE to form the folded lamina shown in Figure 3.

(b) Find the distance of the centre of mass of the folded lamina from BC.

(4)

The folded lamina is freely suspended from D and hangs in equilibrium. The angle between DE and the downward vertical is α.

(c) Find $\tan \alpha$ in terms of a and h.

(4)

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Question 6 continued

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Question 6 continued

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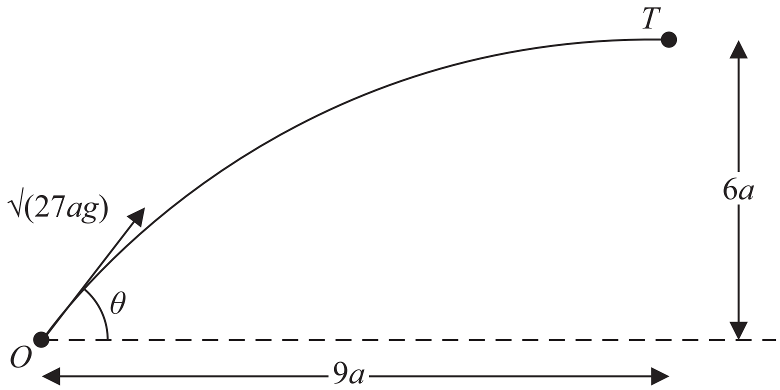

Figure 4

A small ball is projected from a fixed point O so as to hit a target T which is at a horizontal distance $9a$ from O and at a height $6a$ above the level of O. The ball is projected with speed $\sqrt{(27ag)}$ at an angle θ to the horizontal, as shown in Figure 4. The ball is modelled as a particle moving freely under gravity.

(a) Show that $\tan^2 \theta - 6 \tan \theta + 5 = 0$

(7)

The two possible angles of projection are θ_1 and θ_2, where $\theta_1 > \theta_2$.

(b) Find $\tan \theta_1$ and $\tan \theta_2$.

(3)

The particle is projected at the larger angle θ_1.

(c) Show that the time of flight from O to T is $\sqrt{\left(\frac{78a}{g}\right)}$.

(3)

(d) Find the speed of the particle immediately before it hits T.

(3)

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Question 7 continued

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

Thursday 6 June 2013 – Morning

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
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Materials required for examination
Mathematical Formulae (Pink)

Items included with question papers
Nil

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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

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PEARSON

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1. A particle P of mass 2 kg is moving with velocity $(\mathbf{i} - 4\mathbf{j})$ m s^{-1} when it receives an impulse of $(3\mathbf{i} + 6\mathbf{j})$ N s.

Find the speed of P immediately after the impulse is applied.

(5)

Leave blank

2. A particle P of mass 3 kg moves from point A to point B up a line of greatest slope of a fixed rough plane. The plane is inclined at 20° to the horizontal. The coefficient of friction between P and the plane is 0.4

Given that $AB = 15$ m and that the speed of P at A is 20 m s^{-1}, find

(a) the work done against friction as P moves from A to B,

(3)

(b) the speed of P at B.

(4)

Leave blank

3. A particle P moves on the x-axis. At time t seconds the velocity of P is v m s^{-1} in the direction of x increasing, where

$$v = 2t^2 - 14t + 20, \qquad t \geqslant 0$$

Find

(a) the times when P is instantaneously at rest,
(3)

(b) the greatest speed of P in the interval $0 \leqslant t \leqslant 4$
(5)

(c) the total distance travelled by P in the interval $0 \leqslant t \leqslant 4$
(5)

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Question 3 continued

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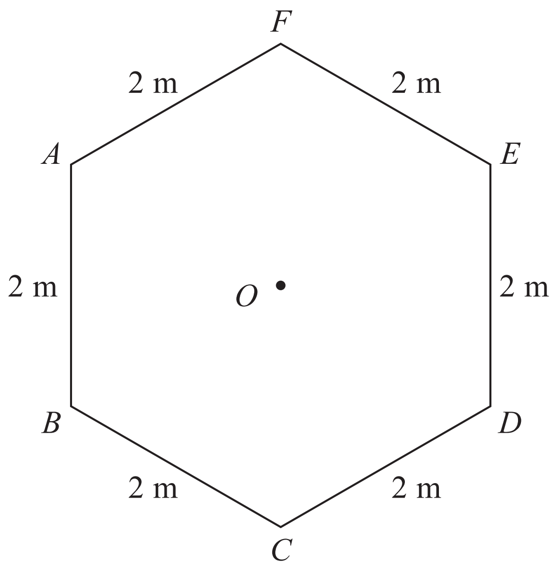

Figure 1

The uniform lamina *ABCDEF* is a regular hexagon with centre *O* and sides of length 2 m, as shown in Figure 1.

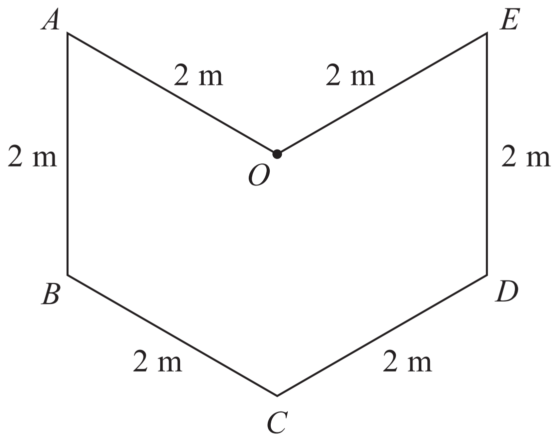

Figure 2

The triangles *OAF* and *OEF* are removed to form the uniform lamina *OABCDE*, shown in Figure 2.

(a) Find the distance of the centre of mass of *OABCDE* from *O*.

(5)

The lamina *OABCDE* is freely suspended from *E* and hangs in equilibrium.

(b) Find the size of the angle between *EO* and the downward vertical.

(6)

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Question 4 continued

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Question 4 continued

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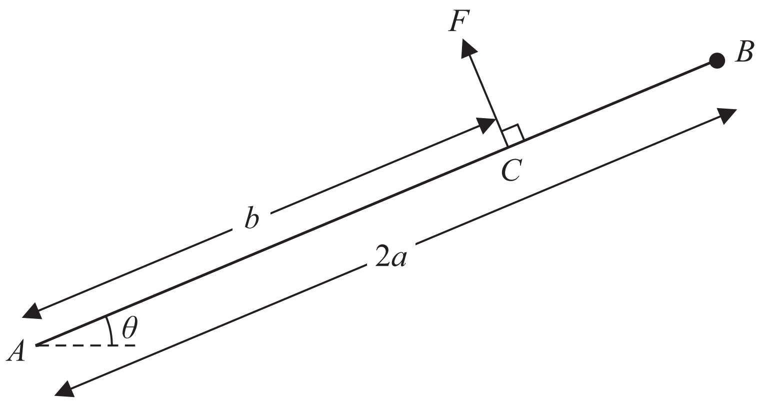

Figure 3

A uniform rod AB, of mass m and length $2a$, is freely hinged to a fixed point A. A particle of mass m is attached to the rod at B. The rod is held in equilibrium at an angle θ to the horizontal by a force of magnitude F acting at the point C on the rod, where $AC = b$, as shown in Figure 3. The force at C acts at right angles to AB and in the vertical plane containing AB.

(a) Show that $F = \dfrac{3amg\cos\theta}{b}$.

(4)

(b) Find, in terms of a, b, g, m and θ,

(i) the horizontal component of the force acting on the rod at A,

(ii) the vertical component of the force acting on the rod at A.

(5)

Given that the force acting on the rod at A acts along the rod,

(c) find the value of $\dfrac{a}{b}$.

(4)

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Question 5 continued

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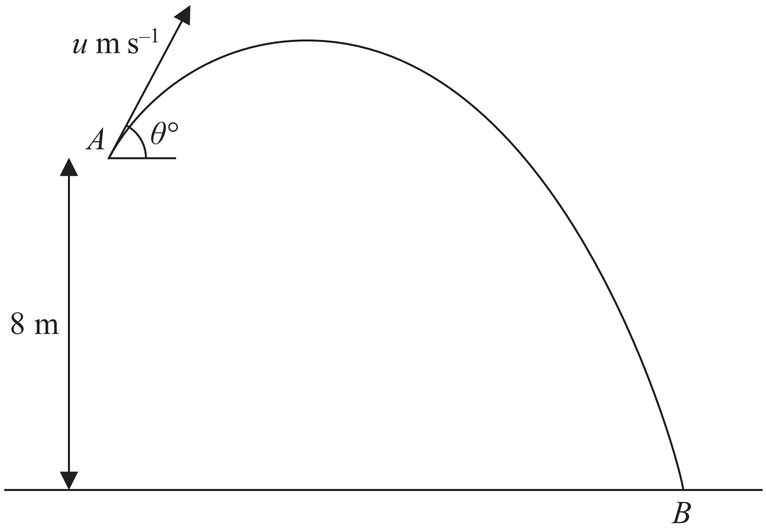

Figure 4

A ball is projected from a point A which is 8 m above horizontal ground as shown in Figure 4. The ball is projected with speed u m s^{-1} at an angle $\theta°$ above the horizontal. The ball moves freely under gravity and hits the ground at the point B. The speed of the ball immediately before it hits the ground is $2u$ m s^{-1}.

(a) By considering energy, find the value of u.

(5)

The time taken for the ball to move from A to B is 2 seconds. Find

(b) the value of θ,

(4)

(c) the minimum speed of the ball on its path from A to B.

(2)

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Question 6 continued

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7. Three particles P, Q and R lie at rest in a straight line on a smooth horizontal table with Q between P and R. The particles P, Q and R have masses $2m$, $3m$ and $4m$ respectively. Particle P is projected towards Q with speed u and collides directly with it. The coefficient of restitution between each pair of particles is e.

(a) Show that the speed of Q immediately after the collision with P is $\frac{2}{5}(1+e)u$.
(6)

After the collision between P and Q there is a direct collision between Q and R.
Given that $e = \frac{3}{4}$, find

(b) (i) the speed of Q after this collision,

(ii) the speed of R after this collision.
(6)

Immediately after the collision between Q and R, the rate of increase of the distance between P and R is V.

(c) Find V in terms of u.
(3)

Leave blank

Question 7 continued