Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number | Candidate Number

Thursday 20 June 2019

Morning (Time: 1 hour 30 minutes) | Paper Reference **9FM0/3C**

Further Mathematics

Advanced

Paper 3C: Further Mechanics 1

You must have:
Mathematical Formulae and Statistical Tables (Green), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for algebraic manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Unless otherwise indicated, whenever a numerical value of g is required, take $g = 9.8\,\text{m}\,\text{s}^{-2}$ and give your answer to either 2 significant figures or 3 significant figures.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 7 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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Pearson

Answer ALL questions. Write your answers in the spaces provided.

1. A van of mass 750 kg is moving up a straight road inclined at an angle β to the horizontal, where $\sin \beta = \frac{1}{21}$. At the instant when the speed of the van is $v\,\text{m s}^{-1}$, the resistance to the motion of the van from non-gravitational forces is modelled as a force of magnitude λv newtons, where λ is a constant. When the engine of the van is working at a constant rate of 13 kW, the van moves up the road at a constant speed of $20\,\text{m s}^{-1}$.

(a) Show that $\lambda = 15$

(4)

Later on, the van is moving along a straight horizontal road. At the instant when the speed of the van is $v\,\text{m s}^{-1}$, the resistance to the motion of the van is modelled as a force of magnitude $15v$ newtons. When the engine of the van is working at a constant rate of 11.25 kW, the speed of the van is $U\,\text{m s}^{-1}$ and the acceleration of the van is $0.1\,\text{m s}^{-2}$.

(b) Find the value of U.

(4)

Question 1 continued

Question 1 continued

Question 1 continued

(Total for Question 1 is 8 marks)

2. A small box is projected with speed 7 m s^{-1} from a point O on a fixed rough inclined plane. The plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{3}{4}$. The box moves up a line of greatest slope of the plane and comes to instantaneous rest at the point A. The coefficient of friction between the box and the plane is $\frac{1}{4}$. In a model of the motion, the box is modelled as a particle.

(a) Show that, after coming to rest at A, the box immediately slides back down the plane.

(2)

The speed of the box at the instant when it returns to O is V m s^{-1}.

Given that $OA = \frac{25}{8}$ m,

(b) use the work-energy principle to find the value of V.

(4)

(c) Suggest one way in which the model can be refined to make it more realistic.

(1)

Question 2 continued

Question 2 continued

Question 2 continued

(Total for Question 2 is 7 marks)

3. A particle of mass 0.5 kg is moving with velocity $(-\mathbf{i} + 2\mathbf{j})\,\text{m s}^{-1}$ when it receives an impulse $\mathbf{I}$ N s. As a result of the impulse, the kinetic energy of the particle increases by 12 J.

Given that $\mathbf{I}$ acts in the direction of $(2\mathbf{i} - \mathbf{j})$, find $\mathbf{I}$.

(7)

Question 3 continued

(Total for Question 3 is 7 marks)

4. Two smooth spheres, A and B, of the same radius, have masses $2m$ and $3m$ respectively. The spheres are at rest on a smooth horizontal plane. Sphere A is projected towards B with speed u and collides directly with B. The coefficient of restitution between the spheres is e, where $e > \frac{2}{3}$

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

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

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

(7)

(b) Describe the direction of motion of A immediately after the collision, justifying your answer.

(1)

Given that $e = \frac{5}{6}$

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

(4)

Question 4 continued

Question 4 continued

Question 4 continued

(Total for Question 4 is 12 marks)

5.

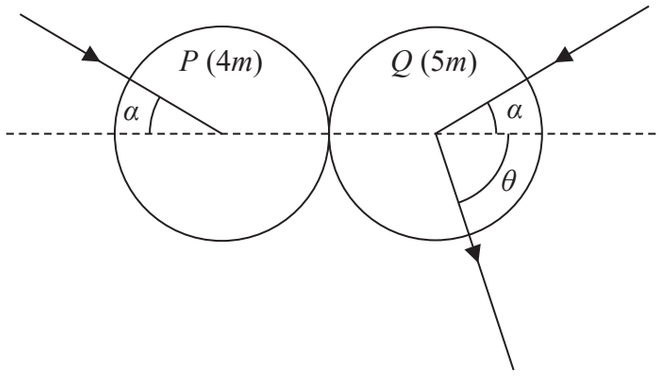

Figure 1

Two smooth uniform spheres, P and Q, with equal radii, are moving on a smooth horizontal plane when they collide. Sphere P has mass $4m$ and sphere Q has mass $5m$. Immediately before they collide, both spheres are moving with the same speed at an angle α, $0° < \alpha < 90°$, to the line joining their centres. Immediately after they collide, Q moves at an angle θ to the line joining their centres, as shown in Figure 1. The coefficient of restitution between the spheres is e.

(a) Show that

$$\tan\theta = \frac{9\tan\alpha}{8e-1}$$

(10)

Given that immediately after the collision, Q moves in a direction that is perpendicular to the line of centres and that $\alpha = 45°$

(b) (i) find the value of e,

(ii) find the direction of motion of P immediately after the collision.

(4)

(c) Explain how you have used the fact that the two spheres have equal radii in your solution to part (a).

(1)

Question 5 continued

Question 5 continued

Question 5 continued

(Total for Question 5 is 15 marks)

6. Two fixed points, A and B, lie on a horizontal ceiling with $AB = 6a$. A light elastic string of modulus of elasticity $\frac{5mg}{3}$ has one end attached to A and the other end attached to B. A particle P of mass $4m$ is attached to the midpoint of the string and P hangs in equilibrium at a distance $4a$ below AB.

(a) Show that the natural length of the string is $4a$.

(5)

The particle P is now held at the midpoint of AB and released from rest.

(b) Find the maximum speed of P as it falls.

(6)

Question 6 continued

Question 6 continued

Question 6 continued

(Total for Question 6 is 11 marks)

7. A small ball is projected with speed $14\,\text{m s}^{-1}$ from a point O on the ground. The ball is projected at an angle α to the ground, where $\tan\alpha = \frac{3}{4}$. The ball bounces on the ground for the first time at the point A_1. The coefficient of restitution between the ball and the ground is $\frac{1}{2}$. The ball is modelled as a particle moving freely under gravity from O to A_1 and between bounces. The ground is modelled as a smooth horizontal plane.

(a) Find the size of the angle between the direction of motion of the ball and the ground immediately after the ball bounces on the ground at A_1

(4)

(b) Explain how, in your calculation, you have used the fact that the ball is moving freely under gravity from O to A_1

(1)

The ball bounces on the ground for the second time at the point A_2

(c) Find the total time taken by the ball to travel from O to A_2

(4)

The ball bounces on the ground for the nth time at the point A_n

Immediately after the ball bounces at A_n, the angle between the direction of motion of the ball and the ground is ϕ.

(d) Find, in terms of n only, an expression for $\tan\phi$.

(3)

(e) Describe, according to the model, the subsequent motion of the ball after it has bounced on the ground at A_2

(1)

Given instead that the coefficient of restitution between the ball and the ground is 0

(f) describe fully the motion of the ball from the instant when it is projected from O.

(2)

Question 7 continued

Question 7 continued

Question 7 continued

Question 7 continued

(Total for Question 7 is 15 marks)

TOTAL FOR PAPER IS 75 MARKS