



Cambridge International AS & A Level

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FURTHER MATHEMATICS

9231/32

Paper 3 Further Mechanics

October/November 2021

1 hour 30 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- If additional space is needed, you should use the lined page at the end of this booklet; the question number or numbers must be clearly shown.
- You should use a calculator where appropriate.
- You must show all necessary working clearly; no marks will be given for unsupported answers from a calculator.
- Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place for angles in degrees, unless a different level of accuracy is specified in the question.
- Where a numerical value for the acceleration due to gravity (g) is needed, use 10 ms^{-2} .

INFORMATION

- The total mark for this paper is 50.
- The number of marks for each question or part question is shown in brackets [].

This document has **16** pages. Any blank pages are indicated.

1 A particle is projected with speed u at an angle α above the horizontal from a point O on a horizontal plane. The particle moves freely under gravity.

(a) Write down the horizontal and vertical components of the velocity of the particle at time T after projection. [2]

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At time T after projection, the direction of motion of the particle is perpendicular to the direction of projection.

(b) Express T in terms of u , g and α . [2]

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(c) Deduce that $T > \frac{u}{g}$. [1]

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- 2 A light spring AB has natural length a and modulus of elasticity $5mg$. The end A of the spring is attached to a fixed point on a smooth horizontal surface. A particle P of mass m is attached to the end B of the spring. The spring and particle P are at rest on the surface.

Another particle Q of mass km is moving with speed $\sqrt{4ga}$ along the horizontal surface towards P in the direction BA . The particles P and Q collide directly and coalesce. In the subsequent motion the greatest amount by which the spring is compressed is $\frac{1}{5}a$.

Find the value of k .

[6]

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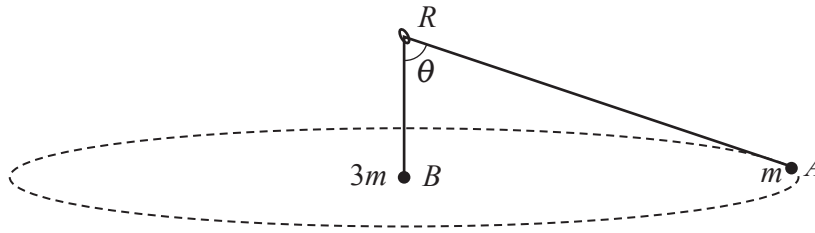
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Particles A and B , of masses m and $3m$ respectively, are connected by a light inextensible string of length a that passes through a fixed smooth ring R . Particle B hangs in equilibrium vertically below the ring. Particle A moves in horizontal circles with speed v . Particles A and B are at the same horizontal level. The angle between AR and BR is θ (see diagram).

(a) Show that $\cos \theta = \frac{1}{3}$. [2]

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(b) Find an expression for v in terms of a and g . [4]

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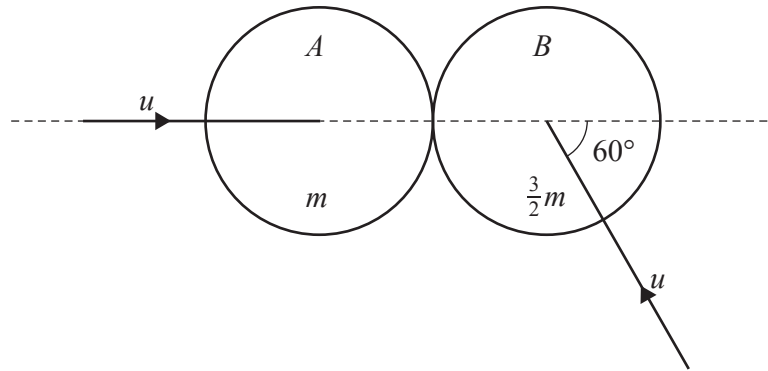
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Two uniform smooth spheres A and B of equal radii have masses m and $\frac{3}{2}m$ respectively. The two spheres are each moving with speed u on a horizontal surface when they collide. Immediately before the collision A 's direction of motion is along the line of centres, and B 's direction of motion makes an angle of 60° with the line of centres (see diagram). The coefficient of restitution between the spheres is $\frac{2}{3}$.

- (a) Find the angle through which the direction of motion of B is deflected by the collision. [6]

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- 6 A particle P of mass 2 kg moves along a horizontal straight line. The point O is a fixed point on this line. At time $t\text{ s}$ the velocity of P is $v\text{ m s}^{-1}$ and the displacement of P from O is $x\text{ m}$.

A force of magnitude $\left(8x - \frac{128}{x^3}\right)\text{ N}$ acts on P in the direction OP . When $t = 0$, $x = 8$ and $v = -15$.

- (a) Show that $v = -\frac{2}{x}(x^2 - 4)$. [5]

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- (b) Find, in terms of m and g , the tension in the string immediately after P is initially projected horizontally. [4]

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