



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)

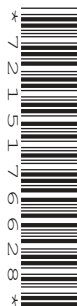
INSTRUCTIONS

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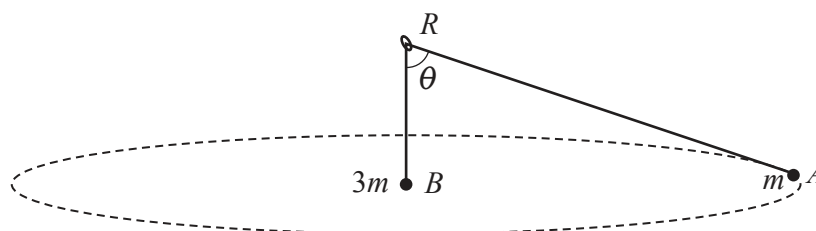
Another particle Q of mass km is moving with speed $\sqrt{4ga}$ along the horizontal surface towards P in the direction BA . The particles P and Q collide directly and coalesce. In the subsequent motion the greatest amount by which the spring is compressed is $\frac{1}{5}a$.

[6]

[illegible]

4

3



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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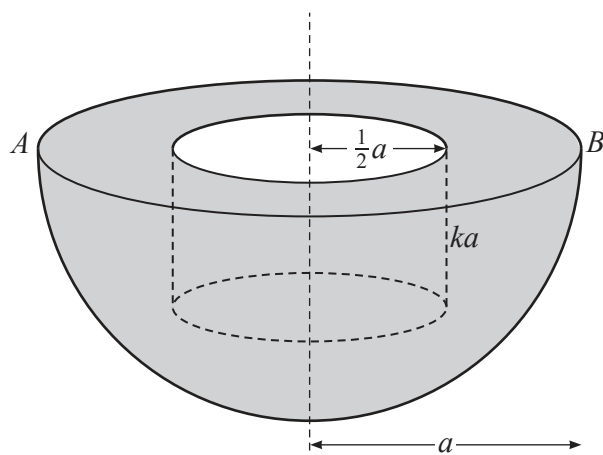
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This image shows a full page of a worksheet designed for handwriting practice. It features approximately 20 evenly spaced horizontal dotted lines across the entire width of the page, providing a guide for letter height and placement. The background is plain white, and there are no other markings or text present.

6

4



An object is formed by removing a solid cylinder, of height ka and radius $\frac{1}{2}a$, from a uniform solid hemisphere of radius a . The axes of symmetry of the hemisphere and the cylinder coincide and one circular face of the cylinder coincides with the plane face of the hemisphere. AB is a diameter of the circular face of the hemisphere (see diagram).

- (a) Show that the distance of the centre of mass of the object from AB is $\frac{3a(2-k^2)}{2(8-3k)}$. [4]

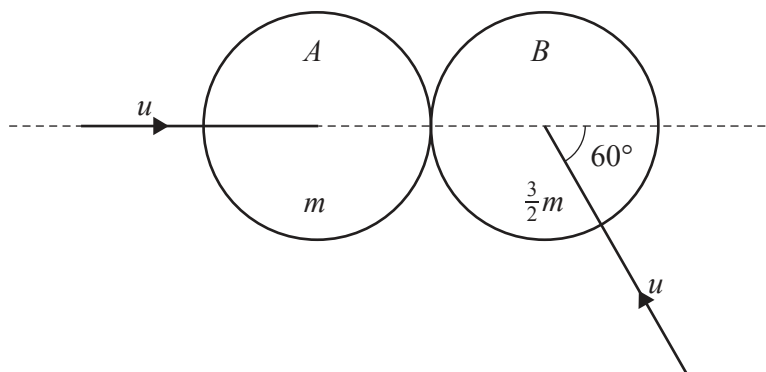
This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

When the object is freely suspended from the point A , the line AB makes an angle θ with the downward vertical, where $\tan \theta = \frac{7}{18}$.

(b) Find the possible values of k . [3]

This image shows a full page of a handwriting practice worksheet. It consists of multiple sets of three horizontal dotted lines, providing a guide for letter height and placement. The lines are evenly spaced across the entire page, leaving ample room for writing practice. There is no text or other markings on the page.

5



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]

[illegible]

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(b) Find the loss in the total kinetic energy of the system as a result of the collision. [3]

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

[illegible]

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- [illegible]

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