



Cambridge International AS & A Level

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MATHEMATICS

9709/04

Paper 4 Mechanics

For examination from 2020

SPECIMEN PAPER

1 hour 15 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 **14** pages. Blank pages are indicated.

1 A particle P is projected vertically upwards with speed 10 ms^{-1} from a point A on the ground

(a) Find the greatest height above the ground reached by P . [2]

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(b) Find the total time from projection until P returns to the ground [2]

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2 A constant resistance of magnitude 8 N acts on a car of mass 1000 kg

(a) The car is moving up a straight level road at a constant speed of 2 ms^{-1} .

Find the rate at which the engine of the car is working [2]

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(b) The car travels at a constant speed down a hill inclined at an angle of θ° to the horizontal, where $\sin \theta = \frac{1}{20}$, with the engine working at 3 kW .

Find the speed of the car. [3]

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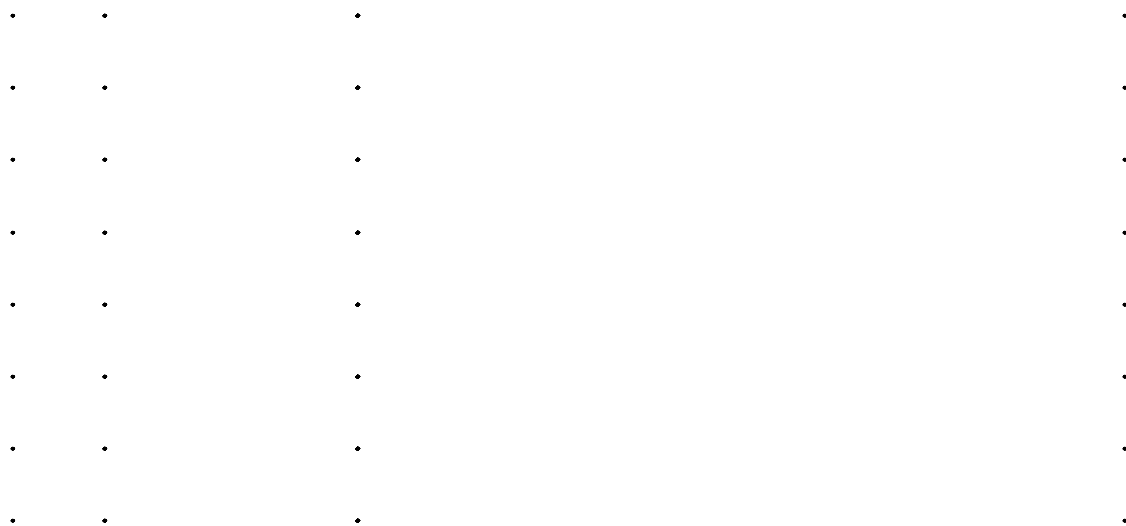
3 Three small smooth spheres A , B and C of equal radii and of masses 4 kg , 2 kg and 3 kg respectively, lie in contact in a straight line on a smooth horizontal plane. Initially, B and C are at rest and A is moving towards B with speed 6 ms^{-1} . After the collision with B , sphere A continues to move in the same direction with speed 2 ms^{-1} .

(a) Find the speed of B after the collision. [2]



Sphere B collides with C . In this collision the two spheres cease to form a projectile D .

(b) Find the speed of D after the collision. [2]



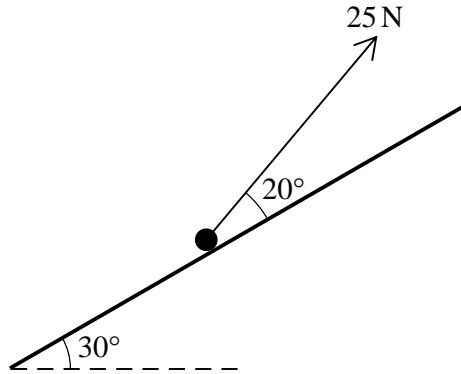
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(c) Show that the total loss of kinetic energy in the system to the two collisions is 8 J. [2]

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4 A particle of mass 0.5 kg is on a rough plane inclined at an angle of 30° to the horizontal. A force of magnitude 25 N , acting at an angle of 20° above a line of greatest slope of the plane, is used to prevent the particle from sliding down the plane. The coefficient of friction between the particle and the plane is μ .

(a) Complete the diagram below to show all the forces acting on the particle. [1]



(b) Find the least possible value of μ . [5]

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5 A car of mass 0.5 kg is pulled by a trailer of mass 0.3 kg parallel to the horizontal. The car and the trailer are connected by a light rigid tow-bar which is parallel to the road. The driving force of the car's engine is 0.6 N and the resistances to the car and trailer are 0.1 N and 0.05 N respectively.

(a) Find the acceleration of the system and the tension in the tow-bar. [4]

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(b) What horizontal force must be applied to the cart to accelerate it to a speed of 0.8 ms^{-1} when the friction force becomes zero?

Find the time, in seconds, before the system comes to rest and the force in the tow-bar during this time. [5]

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6 A particle P moves in a straight line. The velocity v in ms^{-1} at time t seconds is given by

$$v = 5t(t - 2) \quad \text{for } 0 \leq t \leq 4$$

$$v = k \quad \text{for } 4 \leq t \leq 8$$

$$v = 82 - t \quad \text{for } 8 \leq t \leq 10$$

where k is a constant.

(a) Find k . [1]

(b) Sketch the velocity-time graph for $0 \leq t \leq 10$. [3]

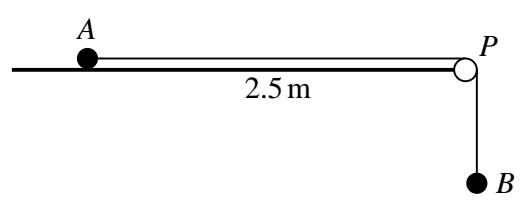
(c) Find the set of values of t for which the acceleration of P is positive. [2]

(d) Find the total distance travelled by the particle in the interval $10 \leq t \leq 20$

[5]

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Two particles A and B, of masses 0.8 kg and 0.4 kg respectively, are connected by a light inextensible string. Particle A is placed on a horizontal surface. The string passes over a small smooth pulley P fixed at the edge of the surface, and B hangs freely. The horizontal section of the string AP, is of length 2.5 m (see diagram). The particles are released from rest with the section of the string at rest.

(a) Given that the surface is smooth, find the time taken for A to reach the pulley. [5]

A series of horizontal dotted lines for writing the solution to part (a).

- (b) It is given in part (a) that the surface is rough and that the speed of A immediately before it reaches the plane is $v \text{ ms}^{-1}$. The work done against friction as A moves from rest to the plane is $2J$.

Use an energy method to find v .

[4]

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