

Cambridge International AS & A Level

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MATHEMATICS

9709/41

Paper 4 Mechanics

May/June 2020

1 hour 15 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

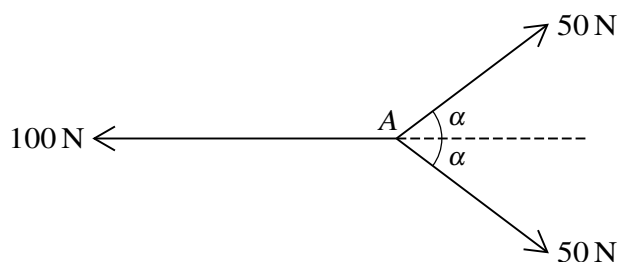
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
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- Do **not** write on any bar codes.
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- 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 m s^{-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. Blank pages are indicated.

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Three coplanar forces of magnitudes 100 N, 50 N and 50 N act at a point A, as shown in the diagram. The value of $\cos \alpha$ is $\frac{4}{5}$.

Find the magnitude of the resultant of the three forces and state its direction. [3]

This image shows a full page of white paper with horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

- 2** A car of mass 1800 kg is towing a trailer of mass 400 kg along a straight horizontal road. The car and trailer are connected by a light rigid tow-bar. The car is accelerating at 1.5 m s^{-2} . There are constant resistance forces of 250 N on the car and 100 N on the trailer.

(a) Find the tension in the tow-bar.

[2]

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(b) Find the power of the engine of the car at the instant when the speed is 20 m s^{-1} .

[3]

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- 3 A particle P is projected vertically upwards with speed 5 m s^{-1} from a point A which is 2.8 m above horizontal ground.

(a) Find the greatest height above the ground reached by P . [3]

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(b) Find the length of time for which P is at a height of more than 3.6 m above the ground. [4]

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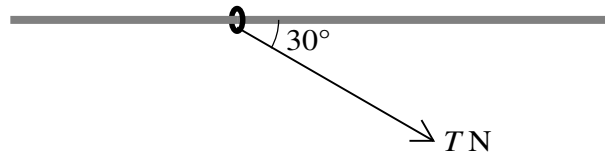
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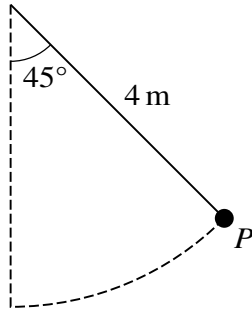


The diagram shows a ring of mass 0.1 kg threaded on a fixed horizontal rod. The rod is rough and the coefficient of friction between the ring and the rod is 0.8 . A force of magnitude $T\text{ N}$ acts on the ring in a direction at 30° to the rod, downwards in the vertical plane containing the rod. Initially the ring is at rest.

- (a) Find the greatest value of T for which the ring remains at rest. [4]

[illegible]

[illegible]



A child of mass 35 kg is swinging on a rope. The child is modelled as a particle P and the rope is modelled as a light inextensible string of length 4 m. Initially P is held at an angle of 45° to the vertical (see diagram).

- (a) Given that there is no resistance force, find the speed of P when it has travelled half way along the circular arc from its initial position to its lowest point. [4]

[illegible]

- (b) It is given instead that there is a resistance force. The work done against the resistance force as P travels from its initial position to its lowest point is X J. The speed of P at its lowest point is 4 m s^{-1} .

Find X .

[3]

[illegible]

- 6** A particle moves in a straight line AB . The velocity $v \text{ m s}^{-1}$ of the particle $t \text{ s}$ after leaving A is given by $v = k(t^2 - 10t + 21)$, where k is a constant. The displacement of the particle from A , in the direction towards B , is 2.85 m when $t = 3$ and is 2.4 m when $t = 6$.
- (a) Find the value of k . Hence find an expression, in terms of t , for the displacement of the particle from A . [7]

[illegible]

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- (b) Find the displacement of the particle from A when its velocity is a minimum. [4]

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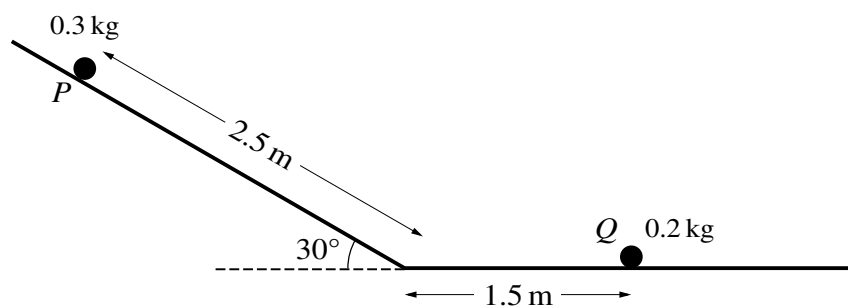
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A particle P of mass 0.3 kg , lying on a smooth plane inclined at 30° to the horizontal, is released from rest. P slides down the plane for a distance of 2.5 m and then reaches a horizontal plane. There is no change in speed when P reaches the horizontal plane. A particle Q of mass 0.2 kg lies at rest on the horizontal plane 1.5 m from the end of the inclined plane (see diagram). P collides directly with Q .

- (a) It is given that the horizontal plane is smooth and that, after the collision, P continues moving in the same direction, with speed 2 m s^{-1} .

Find the speed of Q after the collision.

[5]

This image shows a full page of a handwriting practice worksheet. It consists of multiple sets of three horizontal dashed lines, providing a guide for letter height and placement. The lines are evenly spaced across the entire page, which is otherwise blank white space.

[illegible]

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MATHEMATICS

9709/42

Paper 4 Mechanics

May/June 2020

1 hour 15 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

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- Where a numerical value for the acceleration due to gravity (g) is needed, use 10 m s^{-2} .

INFORMATION

- The total mark for this paper is 50.
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This document has **12** pages. Blank pages are indicated.

- 1** A tram starts from rest and moves with uniform acceleration for 20 s. The tram then travels at a constant speed, $V \text{ m s}^{-1}$, for 170 s before being brought to rest with a uniform deceleration of magnitude twice that of the acceleration. The total distance travelled by the tram is 2.775 km.

(a) Sketch a velocity-time graph for the motion, stating the total time for which the tram is moving. [2]

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(b) Find V . [2]

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(c) Find the magnitude of the acceleration. [2]

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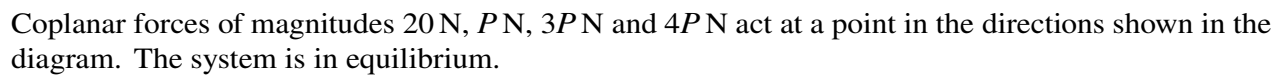
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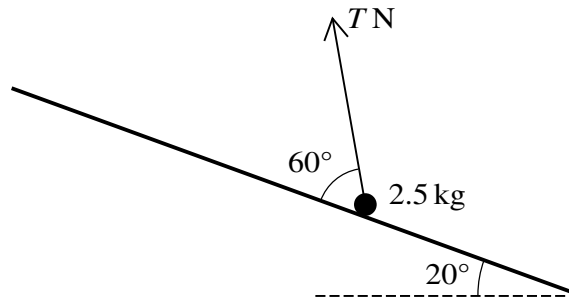
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[6]

[illegible]



Find the greatest and least possible values of T . [8]

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- 4** Small smooth spheres A and B , of equal radii and of masses 4 kg and 2 kg respectively, lie on a smooth horizontal plane. Initially B is at rest and A is moving towards B with speed 10 m s^{-1} . After the spheres collide A continues to move in the same direction but with half the speed of B .

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

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A third small smooth sphere C , of mass 1 kg and with the same radius as A and B , is at rest on the plane. B now collides directly with C . After this collision B continues to move in the same direction but with one third the speed of C .

(b) Show that there is another collision between A and B . [3]

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(c) A and B coalesce during this collision.

Find the total loss of kinetic energy in the system due to the three collisions. [5]

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5 A car of mass 1250 kg is moving on a straight road.

(a) On a horizontal section of the road, the car has a constant speed of 32 m s^{-1} and there is a constant force of 750 N resisting the motion.

(i) Calculate, in kW, the power developed by the engine of the car. [2]

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(ii) Given that this power is suddenly decreased by 8 kW, find the instantaneous deceleration of the car. [3]

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[5]

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- 6 A particle P moves in a straight line. The velocity $v \text{ m s}^{-1}$ at time $t \text{ s}$ is given by

$$\begin{aligned} v &= 2t + 1 && \text{for } 0 \leq t \leq 5, \\ v &= 36 - t^2 && \text{for } 5 \leq t \leq 7, \\ v &= 2t - 27 && \text{for } 7 \leq t \leq 13.5. \end{aligned}$$

- (a) Sketch the velocity-time graph for $0 \leq t \leq 13.5$. [3]

- (b) Find the acceleration at the instant when $t = 6$. [2]

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[5]

This image shows a full page of a handwriting practice worksheet. It consists of multiple sets of three horizontal dotted lines spaced evenly down the page, providing a guide for letter height and placement. The background is plain white, and there are no other markings or text present.

[illegible]

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MATHEMATICS

9709/43

Paper 4 Mechanics

May/June 2020

1 hour 15 minutes

You must answer on the question paper.

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INSTRUCTIONS

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INFORMATION

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This document has **12** pages. Blank pages are indicated.

- 1 Particles P of mass m kg and Q of mass 0.2 kg are free to move on a smooth horizontal plane. P is projected at a speed of 2 m s^{-1} towards Q which is stationary. After the collision P and Q move in opposite directions with speeds of 0.5 m s^{-1} and 1 m s^{-1} respectively.

Find m .

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- 2 A minibus of mass 4000 kg is travelling along a straight horizontal road. The resistance to motion is 900 N.

(a) Find the driving force when the acceleration of the minibus is 0.5 m s^{-2} . [2]

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(b) Find the power required for the minibus to maintain a constant speed of 25 m s^{-1} . [2]

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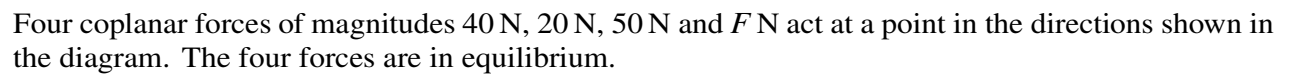
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[6]

This image shows a full page of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page, providing a template for handwriting practice or general writing. There are no margins, text, or other markings on the page.

- 4 A car starts from rest and moves in a straight line with constant acceleration $a \text{ m s}^{-2}$ for a distance of 50 m. The car then travels with constant velocity for 500 m for a period of 25 s, before decelerating to rest. The magnitude of this deceleration is $2a \text{ m s}^{-2}$.

(a) Sketch the velocity-time graph for the motion of the car. [1]



(b) Find the value of a . [3]

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(c) Find the total time for which the car is in motion. [3]

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- (a) Find the decrease in kinetic energy of the block as it moves from P to Q . [2]

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- [illegible]

- (c) At the instant the block reaches Q , the force pushing the block up the slope is removed.

Find the time taken, after this instant, for the block to return to P .

[4]

[illegible]

- 6** A particle travels in a straight line PQ . The velocity of the particle t s after leaving P is v m s⁻¹, where

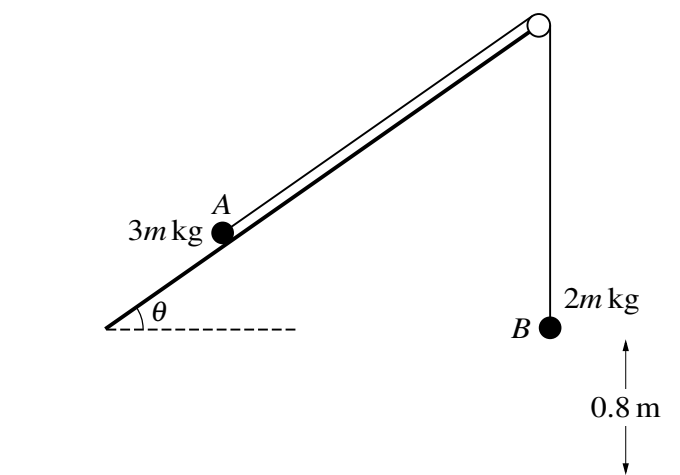
$$v = 4.5 + 4t - 0.5t^2.$$

- (a) Find the velocity of the particle at the instant when its acceleration is zero. [3]

[illegible]

[6]

[illegible]



Two particles A and B , of masses $3m$ kg and $2m$ kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the edge of a plane. The plane is inclined at an angle θ to the horizontal. A lies on the plane and B hangs vertically, 0.8 m above the floor, which is horizontal. The string between A and the pulley is parallel to a line of greatest slope of the plane (see diagram). Initially A and B are at rest.

- (a) Given that the plane is smooth, find the value of θ for which A remains at rest. [3]

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It is given instead that the plane is rough, $\theta = 30^\circ$ and the acceleration of A up the plane is 0.1 m s^{-2} .

- (b) Show that the coefficient of friction between A and the plane is $\frac{1}{10}\sqrt{3}$. [5]

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- (c) When B reaches the floor it comes to rest.

Find the length of time after B reaches the floor for which A is moving up the plane. [You may assume that A does not reach the pulley.] [4]

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