

Cambridge International AS & A Level

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MATHEMATICS

9709/41

Paper 4 Mechanics

October/November 2022

1 hour 15 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

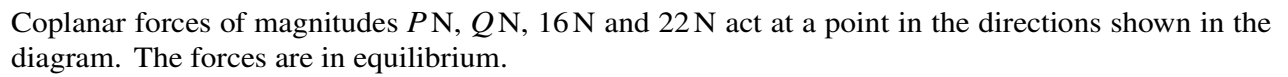
INSTRUCTIONS

- 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.
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- 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 **12** pages.



[5]

[illegible]

- 2 Small smooth spheres A and B , of equal radii and of masses 6 kg and 2 kg respectively, lie on a smooth horizontal plane. Initially A is moving towards B with speed 5 m s^{-1} and B is moving towards A with speed 3 m s^{-1} . After the spheres collide, both A and B move in the same direction and the difference in the speeds of the spheres is 2 m s^{-1} .

Find the loss of kinetic energy of the system due to the collision.

[5]

[illegible]

3 A constant resistance of magnitude 1400 N acts on a car of mass 1250 kg.

- (a) The car is moving along a straight level road at a constant speed of 28 m s^{-1} .

Find, in kW, the rate at which the engine of the car is working.

[2]

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- (b) The car now travels at a constant speed up a hill inclined at an angle of θ to the horizontal, where $\sin \theta = 0.12$, with the engine working at 43.5 kW.

Find this speed.

[3]

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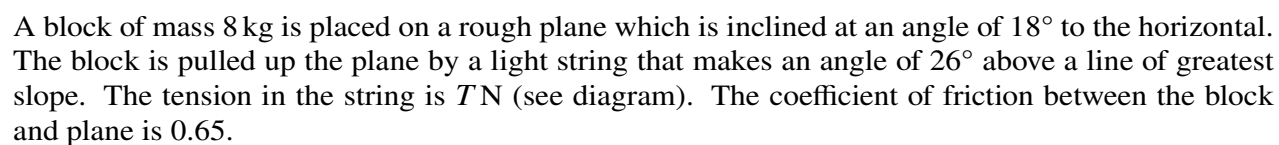
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- (c) On another occasion, the car pulls a trailer of mass 600 kg up the same hill. The system of the car and the trailer is modelled as particles connected by a light inextensible cable. The car's engine produces a driving force of 5000 N and the resistance to the motion of the trailer is 300 N. The resistance to the motion of the car remains 1400 N.

Find the acceleration of the system and the tension in the cable.

[4]

[illegible]



- Find T .

[7]

[illegible]

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(b) The block is initially at rest.

Find the distance travelled by the block during the fourth second of motion. [2]

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- 5 A particle P moves on the x -axis from the origin O with an initial velocity of -20 m s^{-1} . The acceleration $a \text{ m s}^{-2}$ at time $t \text{ s}$ after leaving O is given by $a = 12 - 2t$.

(a) Sketch a velocity-time graph for $0 \leq t \leq 12$, indicating the times when P is at rest. [5]

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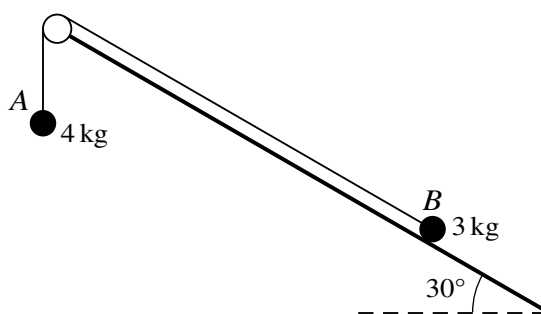


Fig. 6.1 shows particles A and B , of masses 4 kg and 3 kg respectively, attached to the ends of a light inextensible string that passes over a small smooth pulley. The pulley is fixed at the top of a plane which is inclined at an angle of 30° to the horizontal. A hangs freely below the pulley and B is on the inclined plane. The string is taut and the section of the string between B and the pulley is parallel to a line of greatest slope of the plane.

- Find the coefficient of friction between B and the plane.

[6]

[illegible]

(b)

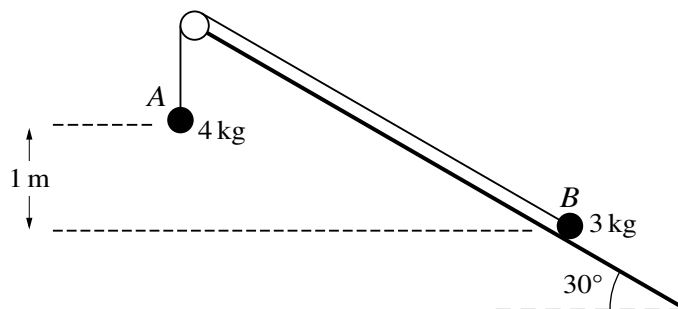


Fig. 6.2

It is given instead that the plane is smooth and the particles are released from rest when the difference in the vertical heights of the particles is 1 m (see Fig. 6.2).

Use an energy method to find the speed of the particles at the instant when the particles are at the same horizontal level. [6]

[illegible]

[illegible]

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Cambridge International AS & A Level

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MATHEMATICS

9709/42

Paper 4 Mechanics

October/November 2022

1 hour 15 minutes

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This document has **12** pages.

- 1** A cyclist is riding a bicycle along a straight horizontal road AB of length 50 m. The cyclist starts from rest at A and reaches a speed of 6 m s^{-1} at B . The cyclist produces a constant driving force of magnitude 100 N. There is a resistance force, and the work done against the resistance force from A to B is 3560 J.

Find the total mass of the cyclist and bicycle.

[3]

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2 A particle P of mass 0.4 kg is in limiting equilibrium on a plane inclined at 30° to the horizontal.

- (a)** Show that the coefficient of friction between the particle and the plane is $\frac{1}{3}\sqrt{3}$. [3]

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A force of magnitude 7.2 N is now applied to P directly up a line of greatest slope of the plane.

- (b)** Given that P starts from rest, find the time that it takes for P to move 1 m up the plane. [4]

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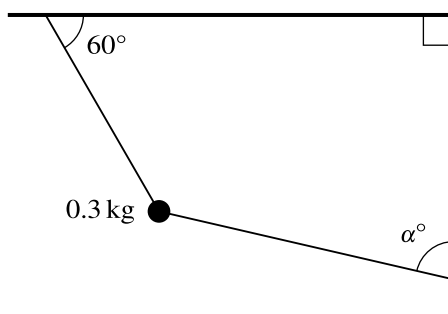
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A particle of mass 0.3 kg is held at rest by two light inextensible strings. One string is attached at an angle of 60° to a horizontal ceiling. The other string is attached at an angle α° to a vertical wall (see diagram). The tension in the string attached to the ceiling is 4 N .

Find the tension in the string which is attached to the wall and find the value of α . [6]

[illegible]

- 4** A car of mass 1200 kg is travelling along a straight horizontal road AB . There is a constant resistance force of magnitude 500 N . When the car passes point A , it has a speed of 15 m s^{-1} and an acceleration of 0.8 m s^{-2} .

(a) Find the power of the car's engine at the point A . [3]

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The car continues to work with this power as it travels from A to B . The car takes 53 seconds to travel from A to B and the speed of the car at B is 32 m s^{-1} .

(b) Show that the distance AB is 1362.6 m . [3]

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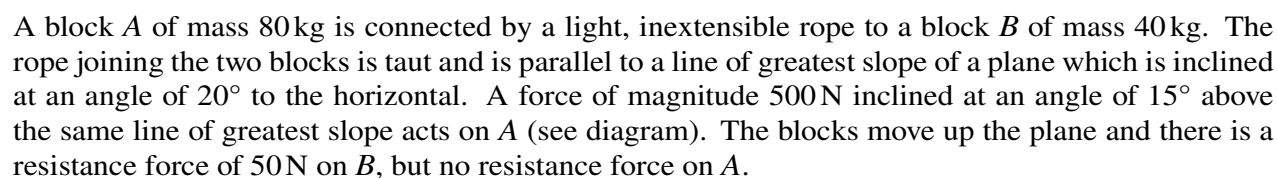
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- (b) Find the time that it takes for the blocks to reach a speed of 1.2 m s^{-1} from rest. [2]

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- (a)** Show that the speed of B after the collision is 1.05 m s^{-1} . [2]

(b) Find m . [2]

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- (c) Find the time that it takes, from the instant when B and C collide, until A collides with the combined particle. [5]

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.

- 7 A particle P travels in a straight line, starting at rest from a point O . The acceleration of P at time t s after leaving O is denoted by $a \text{ m s}^{-2}$, where

$$\begin{aligned} a &= 0.3t^{\frac{1}{2}} & \text{for } 0 \leq t \leq 4, \\ a &= -kt^{-\frac{3}{2}} & \text{for } 4 < t \leq T, \end{aligned}$$

where k and T are constants.

- (a) Find the velocity of P at $t = 4$. [2]

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- (b) It is given that there is no change in the velocity of P at $t = 4$ and that the velocity of P at $t = 16$ is 0.3 m s^{-1} .

Show that $k = 2.6$ and find an expression, in terms of t , for the velocity of P for $4 \leq t \leq T$. [4]

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- (c) Given that P comes to instantaneous rest at $t = T$, find the exact value of T . [2]

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- (d) Find the total distance travelled between $t = 0$ and $t = T$. [4]

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[illegible]

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MATHEMATICS

9709/43

Paper 4 Mechanics

October/November 2022

1 hour 15 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

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INFORMATION

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

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- 1 A particle P is projected vertically upwards with speed $u \text{ m s}^{-1}$ from a point on the ground. P reaches its greatest height after 3 s.

(a) Find u . [1]

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(b) Find the greatest height of P above the ground. [2]

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- 2** A box of mass 5 kg is pulled at a constant speed of 1.8 m s^{-1} for 15 s up a rough plane inclined at an angle of 20° to the horizontal. The box moves along a line of greatest slope against a frictional force of 40 N. The force pulling the box is parallel to the line of greatest slope.

(a) Find the change in gravitational potential energy of the box. [2]

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(b) Find the work done by the pulling force. [2]

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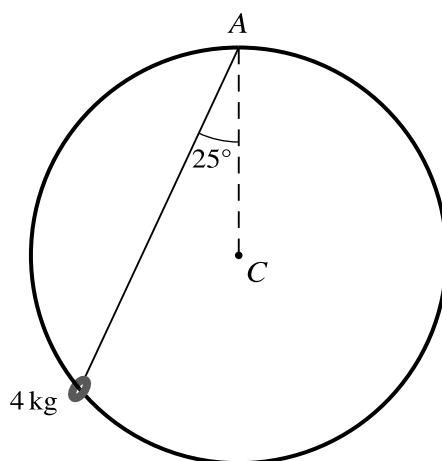
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Find the tension in the string and the magnitude of the normal reaction of the wire on the ring. [6]

[illegible]

- 4 A particle P travels in the positive direction along a straight line with constant acceleration. P travels a distance of 52 m during the 2nd second of its motion and a distance of 64 m during the 4th second of its motion.

(a) Find the initial speed and the acceleration of P .

[5]

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- (b) Find the distance travelled by P during the first 10 seconds of its motion. [2]

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- 5** Particles X and Y move in a straight line through points A and B . Particle X starts from rest at A and moves towards B . At the same instant, Y starts from rest at B .

At time t seconds after the particles start moving

- the acceleration of X in the direction AB is given by $(12t + 12) \text{ m s}^{-2}$,
- the acceleration of Y in the direction AB is given by $(24t - 8) \text{ m s}^{-2}$.

- (a)** It is given that the velocities of X and Y are equal when they collide.

Calculate the distance AB .

[6]

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(b) It is given instead that $AB = 36$ m.

Verify that X and Y collide after 3 s.

[2]

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- 6** A car of mass 1750 kg is pulling a caravan of mass 500 kg. The car and the caravan are connected by a light rigid tow-bar. The resistances to the motion of the car and caravan are 650 N and 150 N respectively.

(a) The car and caravan are moving along a straight horizontal road at a constant speed of 24 m s^{-1} .

(i) Find the power of the car's engine. [2]

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(ii) The engine's power is now suddenly increased to 40 kW.

Find the instantaneous acceleration of the car and caravan and find the tension in the tow-bar. [5]

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- (b) The car and caravan now travel up a straight hill, inclined at an angle $\sin^{-1} 0.14$ to the horizontal, at a constant speed of $v \text{ m s}^{-1}$. The car's engine is working at 31 kW. The resistances to the motion of the car and caravan are unchanged.

Find v .

[3]

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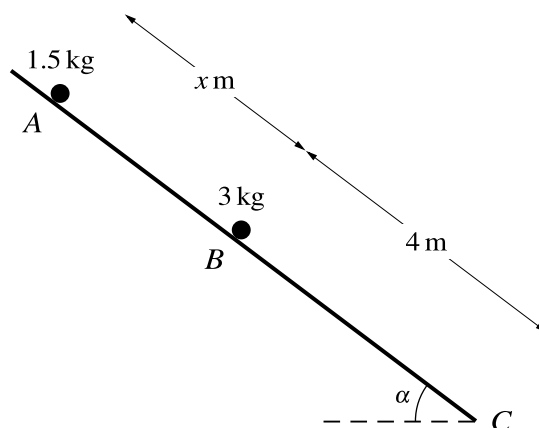
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Particles of masses 1.5 kg and 3 kg lie on a plane which is inclined at an angle of α to the horizontal, where $\tan \alpha = \frac{3}{4}$. The section of the plane from A to B is smooth and the section of the plane from B to C is rough. The 1.5 kg particle is held at rest at A and the 3 kg particle is in limiting equilibrium at B . The distance AB is x m and the distance BC is 4 m (see diagram).

- (a) Show that the coefficient of friction between the particle at B and the plane is 0.75. [3]

[illegible]

The 1.5 kg particle is released from rest. In the subsequent motion the two particles collide and coalesce. The time taken for the combined particle to travel from B to C is 2 s. The coefficient of friction between the combined particle and the plane is still 0.75.

- (b) Find x . [6]

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- (c) Find the total loss of energy of the particles from the time the 1.5 kg particle is released until the combined particle reaches C . [3]

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