Cambridge International AS & A Level

CANDIDATE
NAME

CENTRE
NUMBER

CANDIDATE
NUMBER

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.
- 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 $10 \, \text{m s}^{-2}$.

INFORMATION

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

[Turn over

1

16 N

Q N

55°

25°

22 N

P N
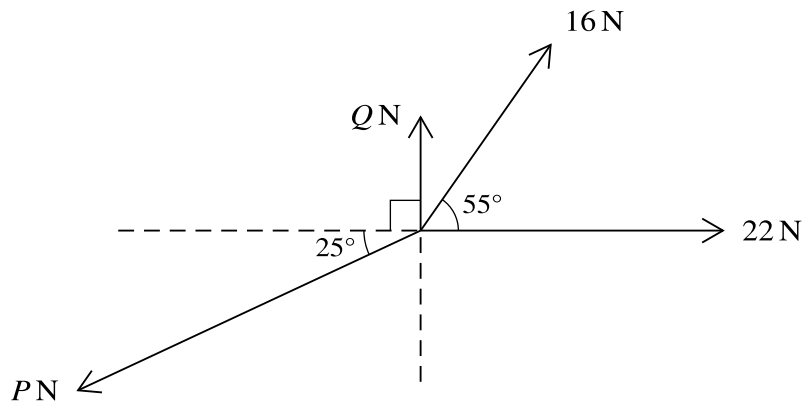
Coplanar forces of magnitudes P N, Q N, 16 N and 22 N act at a point in the directions shown in the diagram. The forces are in equilibrium.

Find the values of P and Q. [5]

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

Find the loss of kinetic energy of the system due to the collision. [5]

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3 A constant resistance of magnitude $1400\,\text{N}$ acts on a car of mass $1250\,\text{kg}$.

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

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 $43.5\,\text{kW}$.

Find this speed. [3]

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(c) On another occasion, the car pulls a trailer of mass $600\,\text{kg}$ 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 $5000\,\text{N}$ and the resistance to the motion of the trailer is $300\,\text{N}$. The resistance to the motion of the car remains $1400\,\text{N}$.

Find the acceleration of the system and the tension in the cable. [4]

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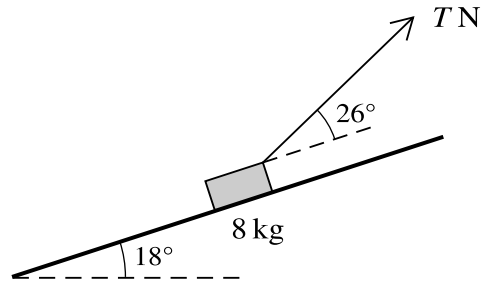
4

A block of mass 8 kg is placed on a rough plane which is inclined at an angle of 18° to the horizontal. The block is pulled up the plane by a light string that makes an angle of 26° above a line of greatest slope. The tension in the string is T N (see diagram). The coefficient of friction between the block and plane is 0.65.

(a) The acceleration of the block is $0.2 \, \text{m s}^{-2}$.

Find T. [7]

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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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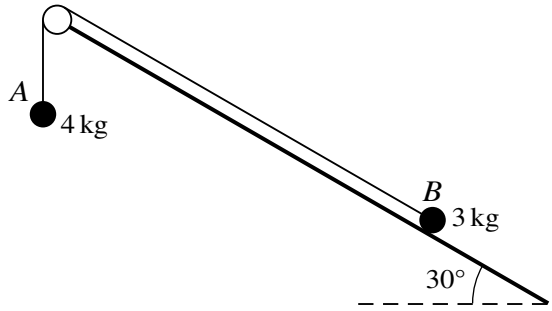...

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

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

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(b) Find the total distance travelled by P in the interval $0 \leqslant t \leqslant 12$. [5]

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Fig. 6.1

Fig. 6.1 shows particles A and B, of masses $4\,\text{kg}$ and $3\,\text{kg}$ 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.

(a) It is given that the plane is rough and the particles are in limiting equilibrium.

Find the coefficient of friction between B and the plane. [6]

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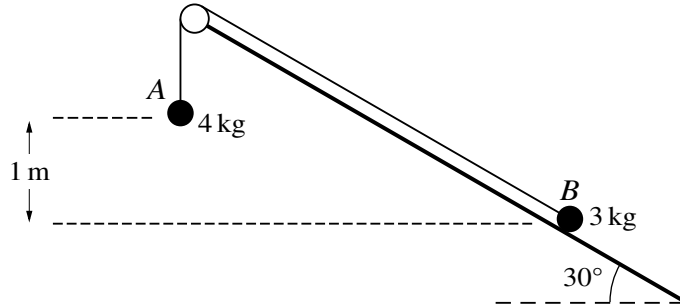
(b)

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]

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Additional Page

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