



## Cambridge International AS & A Level

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**MATHEMATICS**

**9709/41**

Paper 4 Mechanics

**October/November 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.
- 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 [ ].

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

**1** A particle  $B$  of mass  $5\text{ kg}$  is at rest on a smooth horizontal table. A particle  $A$  of mass  $2.5\text{ kg}$  moves on the table with a speed of  $6\text{ m s}^{-1}$  and collides directly with  $B$ . In the collision the two particles coalesce.

**(a)** Find the speed of the combined particle after the collision. [2]

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**(b)** Find the loss of kinetic energy of the system due to the collision. [3]

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## 3

2 A car of mass 1400 kg is moving along a straight horizontal road against a resistance of magnitude 350 N.

(a) Find, in kW, the rate at which the engine of the car is working when it is travelling at a constant speed of  $20 \text{ m s}^{-1}$ . [2]

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(b) Find the acceleration of the car when its speed is  $20 \text{ m s}^{-1}$  and the engine is working at 15 kW. [3]

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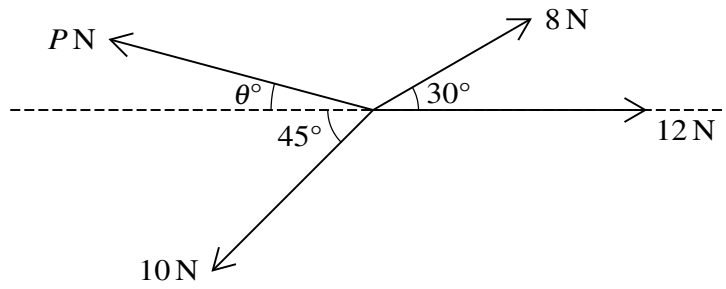
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Coplanar forces of magnitudes 8 N, 12 N, 10 N and  $P$  N act at a point in the directions shown in the diagram. The system is in equilibrium.

Find  $P$  and  $\theta$ . [6]

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- 4 A particle  $P$  moves in a straight line. It starts from rest at a point  $O$  on the line and at time  $t$  s after leaving  $O$  it has acceleration  $a$  m s<sup>-2</sup>, where  $a = 6t - 18$ .

Find the distance  $P$  moves before it comes to instantaneous rest. [6]

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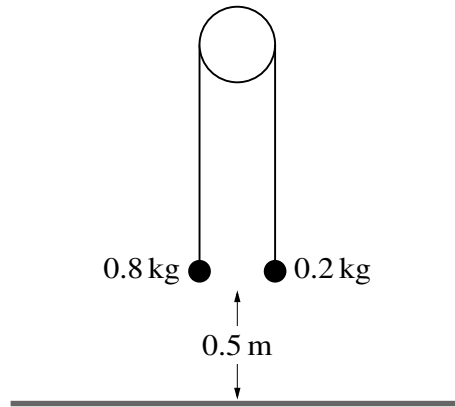
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Two particles of masses 0.8 kg and 0.2 kg are connected by a light inextensible string that passes over a fixed smooth pulley. The system is released from rest with both particles 0.5 m above a horizontal floor (see diagram). In the subsequent motion the 0.2 kg particle does not reach the pulley.

- (a) Show that the magnitude of the acceleration of the particles is  $6 \text{ m s}^{-2}$  and find the tension in the string. [4]

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(b) When the 0.8 kg particle reaches the floor it comes to rest.

Find the greatest height of the 0.2 kg particle above the floor. [3]

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6 A car of mass 1500 kg is pulling a trailer of mass 750 kg up a straight hill of length 800 m inclined at an angle of  $\sin^{-1} 0.08$  to the horizontal. The resistances to the motion of the car and trailer are 400 N and 200 N respectively. The car and trailer are connected by a light rigid tow-bar. The car and trailer have speed  $30 \text{ m s}^{-1}$  at the bottom of the hill and  $20 \text{ m s}^{-1}$  at the top of the hill.

(a) Use an energy method to find the constant driving force as the car and trailer travel up the hill. [5]

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After reaching the top of the hill the system consisting of the car and trailer travels along a straight level road. The driving force of the car's engine is 2400 N and the resistances to motion are unchanged.

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

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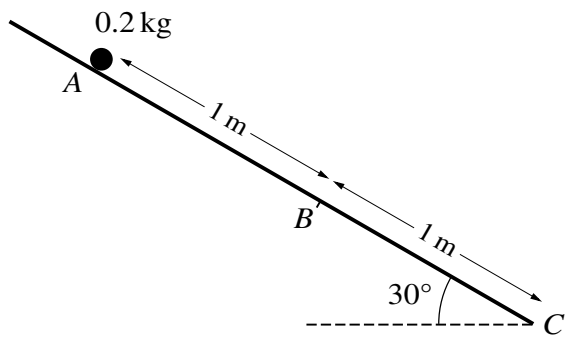
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Three points  $A$ ,  $B$  and  $C$  lie on a line of greatest slope of a plane inclined at an angle of  $30^\circ$  to the horizontal, with  $AB = 1\text{ m}$  and  $BC = 1\text{ m}$ , as shown in the diagram. A particle of mass  $0.2\text{ kg}$  is released from rest at  $A$  and slides down the plane. The part of the plane from  $A$  to  $B$  is smooth. The part of the plane from  $B$  to  $C$  is rough, with coefficient of friction  $\mu$  between the plane and the particle.

(a) Given that  $\mu = \frac{1}{2}\sqrt{3}$ , find the speed of the particle at  $C$ . [8]

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(b) Given instead that the particle comes to rest at  $C$ , find the exact value of  $\mu$ . [4]

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