Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

8733449616

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

INFORMATION

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

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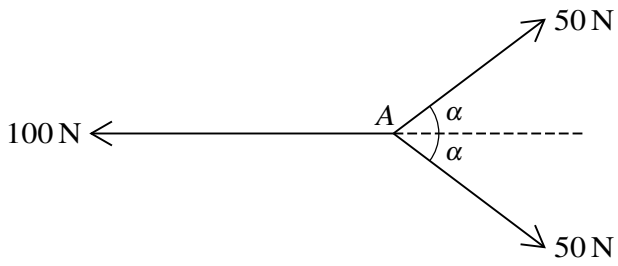

Three coplanar forces of magnitudes 100 N, 50 N and 50 N act at a point A, as shown in the diagram. The value of $\cos\alpha$ is $\frac{4}{5}$.

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

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 $1.5\,\text{m s}^{-2}$. 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 $20\,\text{m s}^{-1}$. [3]

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3 A particle P is projected vertically upwards with speed $5\,\text{m}\,\text{s}^{-1}$ 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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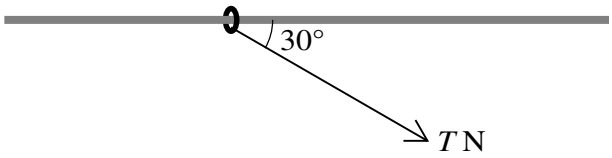

The diagram shows a ring of mass 0.1 kg threaded on a fixed horizontal rod. The rod is rough and the coefficient of friction between the ring and the rod is 0.8. A force of magnitude T N acts on the ring in a direction at 30° to the rod, downwards in the vertical plane containing the rod. Initially the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

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

(b) Find the acceleration of the ring when $T = 3$. [3]

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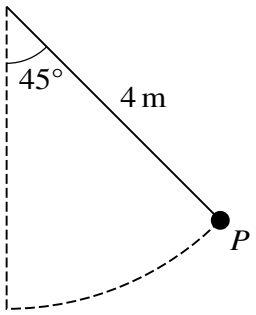

A child of mass 35 kg is swinging on a rope. The child is modelled as a particle P and the rope is modelled as a light inextensible string of length 4 m. Initially P is held at an angle of 45° to the vertical (see diagram).

(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]

(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 $4\,\text{m}\,\text{s}^{-1}$.

Find X. [3]

6 A particle moves in a straight line AB. The velocity v m s^{-1} of the particle t 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]

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

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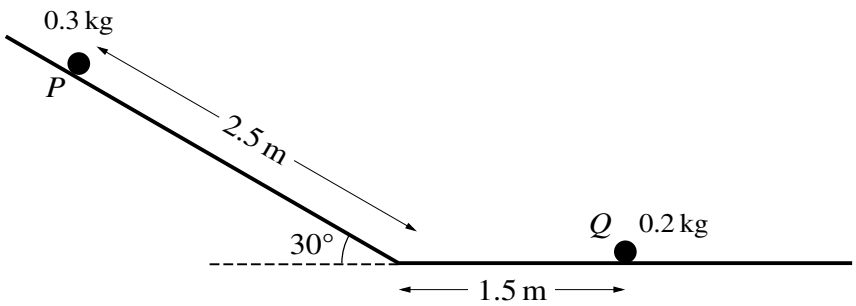

A particle P of mass 0.3 kg, lying on a smooth plane inclined at 30° to the horizontal, is released from rest. P slides down the plane for a distance of 2.5 m and then reaches a horizontal plane. There is no change in speed when P reaches the horizontal plane. A particle Q of mass 0.2 kg lies at rest 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 $2\,\text{m}\,\text{s}^{-1}$.

Find the speed of Q after the collision. [5]

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(b) It is given instead that the horizontal plane is rough and that when P and Q collide, they coalesce and move with speed $1.2\,\text{m}\,\text{s}^{-1}$.

Find the coefficient of friction between P and the horizontal plane. [5]

Additional Page

If you use the following lined page to complete the answer(s) to any question(s), the question number(s) must be clearly shown.

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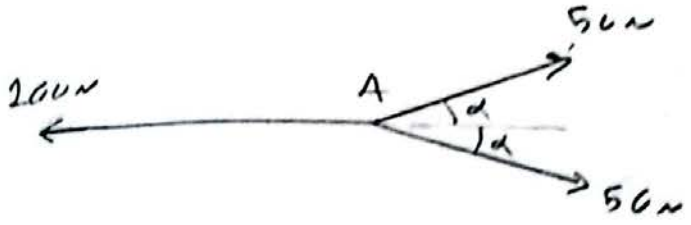
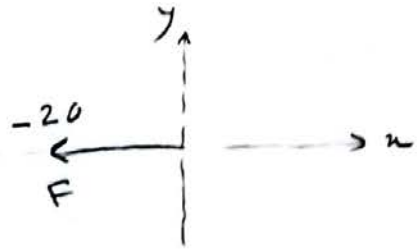
Question 1:



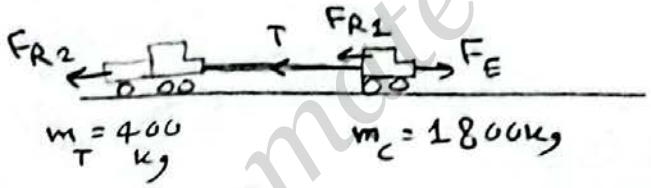
$\Sigma F_x =$

$\Sigma F_x = 2 \times 50\cos\alpha - 100 \Rightarrow (\cos\alpha = 4/5) \Rightarrow 100 \times 4/5 - 100 = \Sigma F_x$



$\Rightarrow |\vec{F}| = 20\,N$ (resultant force) direction $\theta = 180°$

Question 2:



a) $\Sigma F_x = m_C a$ (car) $\Rightarrow F_E - F_{R_1} - T = 1800a$ (I)

$\Sigma F_x = m_T a$ (Trailer) $\rightarrow T - F_{R_2} = 400a$ (II)

$\Rightarrow$ (I): $F_E - 250 - T = 1800 \times 3/2 \Rightarrow F_E - T = 2700 + 250 = 2950$

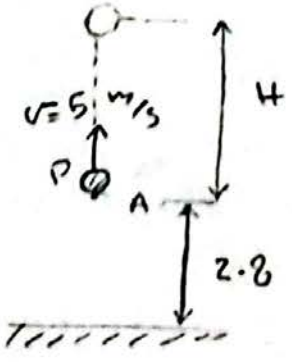
(II): $T - 100 = 400 \times 3/2 = 600 \Rightarrow T = 700\,N$

b) Power = force × speed $\Rightarrow F_{Engine} = T + 2950 = 3650$

$\Rightarrow P = 3650 \times 20 = 73000\,w = 73kw$

Question 3:

a)



$a = -10\,m/s^2$

$\Rightarrow v = at + v_0$

$\Rightarrow t = 5/10 = 0.5\,s$

$\Rightarrow H = \frac{1}{2}at^2 + v_0 t \Rightarrow H = -5(0.5)^2 + 5 \times 0.5 = 1.25\,m$

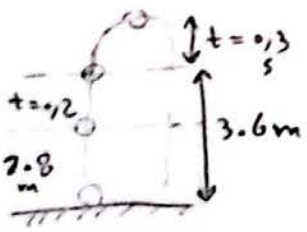
=) total Height = 2.8 + 1.25 = 4.05m

b) 3.6 - 2.8 = 0,8 m (distance for Particle to reach)

$0,8 = \frac{1}{2}at^2 + v_0 t = -5t^2 + 5t \Rightarrow 5t^2 - 5t + 0,8 = 0$

$t = \frac{5 \pm \sqrt{25-16}}{10} = 0,8\,s$ or $0,2\,s$

$t = 0,8\,s$ is not acceptable because the whole time to reach the highest Point is 0,6 s

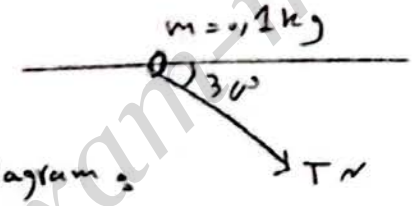


=) t = 0,2 s =) the length of time for which P is at a height more than 3.6 m =

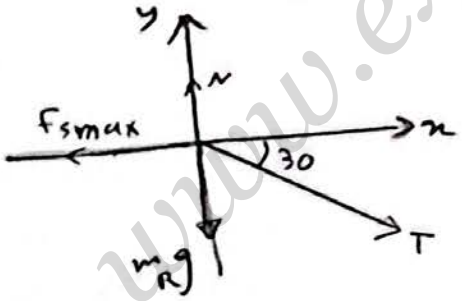
$2(t_{\text{Highest Point}} - t_{\text{reach to 3.6}}) = 2(0,5 - 0,2) = 0,6\,s$

Question (4):

a)



force-body diagram for the ring



$\Sigma F_x = 0$ (remains at rest)

$T\cos 30 - f_{s\max} = 0$

$\Rightarrow T \times \frac{\sqrt{3}}{2} = N \mu_s$ (I)

$\Sigma F_y = 0 \Rightarrow mg + T\sin 30 = N$

$\Rightarrow N = 1 + T/2$

(I): $\frac{\sqrt{3}}{2}T = 0,8 + 0,4T$

$\Rightarrow 0,466T = 0,8 \Rightarrow$

$T = 1.71\,N$

b) $\Sigma F_x = ma \Rightarrow T\cos 30 - f_{s\max} = ma \Rightarrow 0,1a = 2.59 - 2.5 \times 8/10 \Rightarrow$

$\Sigma F_y = 0 \Rightarrow T/2 + mg = N \Rightarrow N = 1 + T/2 = 2.5N$

$a = 5.98\,m/s^2$