3. A particle P of mass m kg is initially held at rest at the point O on a smooth inclined plane. The plane is inclined at an angle α to the horizontal, where $\sin\alpha = \frac{2}{5}$

The particle is released from rest and slides down the plane against a force which acts towards O. The force has magnitude $\frac{1}{3}mx^2$ N, where x metres is the distance of P from O.

(a) Find the speed of P when $x = 2$

(6)

The particle first comes to instantaneous rest at the point A.

(b) Find the distance OA.

(2)

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5. A particle P of mass 0.8 kg moves along the x-axis in the positive x direction under the action of a resultant force. This force acts in the direction of x increasing. At time t seconds, $t \geqslant 0$, P is x metres from the origin O, P is moving with speed v m s^{-1} and the force has magnitude $\dfrac{4}{(x+1)^3}$ N.

When $t = 0$, P is at rest at O.

(a) Show that $v^2 = 5\left(\dfrac{(x+1)^2 - 1}{(x+1)^2}\right)$

(6)

When $t = 2$, P is at the point A. When $t = 4$, P is at the point B.

(b) Using algebraic integration, find the distance AB.

(7)

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3. **In this question you must show all stages of your working.**

Solutions relying entirely on calculator technology are not acceptable.

A particle P is moving along a straight line.

At time t seconds, P is a distance x metres from a fixed point O on the line and is moving away from O with speed $\frac{50}{2x+3}$ m s^{-1}

(a) Find the deceleration of P when $x = 12$

(5)

Given that $x = 4$ when $t = 1$

(b) find the value of t when $x = 12$

(5)

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3: A particle P moves along the x-axis.

At time t seconds, where $t \geqslant 1$

- the displacement of P from O is x metres in the positive x direction, where $x < \frac{1}{2}$
- the velocity of P is v m s^{-1} in the positive x direction
- the acceleration of P is a m s^{-2} in the positive x direction

Given that

$$a = 4x - 2$$

and that when $t = 1$, $x = 0$ and $v = 1$

(a) find v in terms of x,

(4)

(b) find v in terms of t.

(5)

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3. A particle P of mass 0.4 kg moves along the x-axis in the positive direction. At time $t = 0$, P passes through the origin O with speed 10 m s^{-1}. At time t seconds P is x metres from O and the speed of P is v m s^{-1}. The resultant force acting on P has magnitude $\frac{8}{(t+4)^2}$ N and is directed towards O.

(a) Show that $v = \frac{20}{t+4} + 5$

(5)

When $v = 6$, $x = a + b\ln 5$, where a and b are integers.

(b) Using algebraic integration, find the value of a and the value of b.

(5)

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3. A particle P is moving along the x-axis.

At time t seconds, where $t \geqslant 0$, the displacement of P from the origin O is x metres and P is moving with velocity $v\,\text{m s}^{-1}$ in the positive x direction.

The acceleration of P is $\frac{3\sqrt{x+1}}{4}\,\text{m s}^{-2}$ in the positive x direction.

When $t = 0$, $x = 15$ and $v = 8$

(a) Show that $v = (x+1)^{\frac{3}{4}}$

(4)

(b) Find t in terms of v.

(5)

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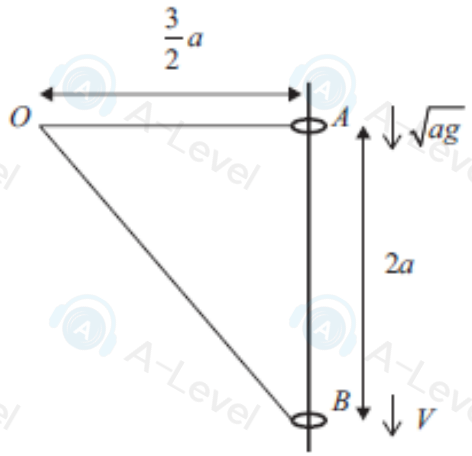


Figure 2

A light elastic string has natural length a and modulus of elasticity mg.
One end of the elastic string is attached to a fixed point O.
The other end is attached to a small smooth ring of mass m.

The ring is threaded on a fixed smooth vertical pole which is a distance $\frac{3}{2}a$ from O.

Initially, the ring is held at the point A on the pole with the elastic string horizontal.

The ring is then projected vertically downwards with speed $\sqrt{ag}$ and reaches the point B, where $AB = 2a$, with speed V, as shown in Figure 2.
Air resistance is assumed to be negligible.

Find V in terms of a and g.

(7)

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5. A vertical ladder is fixed to a wall in a harbour. On a particular day the minimum depth of water in the harbour occurs at 0900 hours. The next time the water is at its minimum depth is 2115 hours on the same day. The bottom step of the ladder is 1 m above the lowest level of the water and 9 m below the highest level of the water. The rise and fall of the water level can be modelled as simple harmonic motion and the thickness of the step can be assumed to be negligible.

Find

(a) the speed, in metres per hour, at which the water level is moving when it reaches the bottom step of the ladder,

(7)

(b) the length of time, on this day, between the water reaching the bottom step of the ladder and the ladder being totally out of the water once more.

(4)

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1. A light elastic string of modulus of elasticity 29.4N has one end attached to a fixed point A. A particle P of mass 1.5kg is attached to the other end of the string and P hangs freely in equilibrium 0.5m vertically below A. Find the natural length of the string.

(4)

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