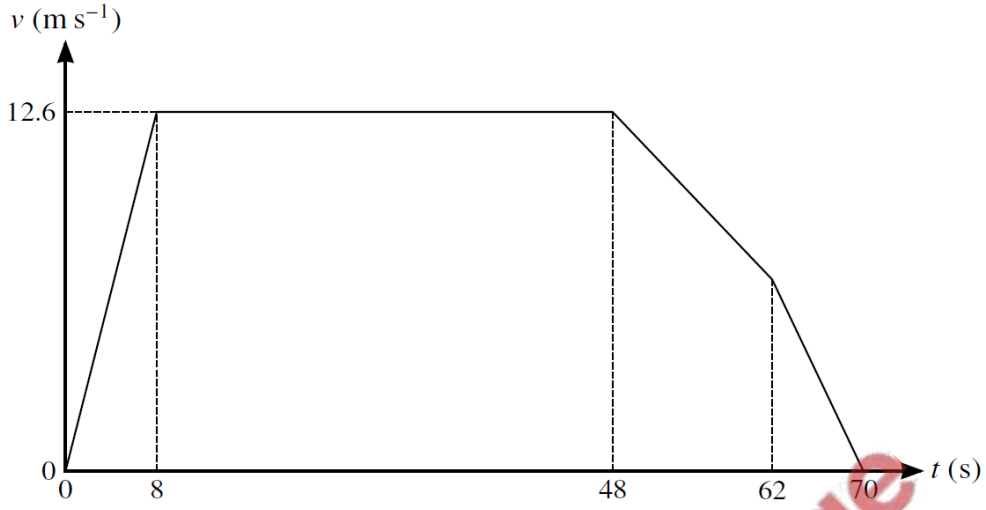
Kinematics – 2023 AS Mathematics 9709

1. Nov/2023/Paper_9709/41/No.3



The diagram shows the velocity-time graph for the motion of a bus. The bus starts from rest and accelerates uniformly for 8 seconds until it reaches a speed of $12.6\,\text{m s}^{-1}$. The bus maintains this speed for 40 seconds. It then decelerates uniformly in two stages. Between 48 and 62 seconds the bus decelerates at $a\,\text{m s}^{-2}$ and between 62 and 70 seconds it decelerates at $2a\,\text{m s}^{-2}$ until coming to rest.

(a) Find the distance covered by the bus in the first 8 seconds. [1]

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(b) Find the value of a. [3]

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(c) Find the average speed of the bus for the whole journey. [4]

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2. Nov/2023/Paper_9709/41/No.7

A particle moves in a straight line starting from a point O before coming to instantaneous rest at a point X. At time t s after leaving O, the velocity v m s^{-1} of the particle is given by

$$v = 7.2t^2 \qquad 0 \leqslant t \leqslant 2,$$
$$v = 30.6 - 0.9t \qquad 2 \leqslant t \leqslant 8,$$
$$v = \frac{1600}{t^2} + kt \qquad 8 \leqslant t,$$

where k is a constant. It is given that there is no instantaneous change in velocity at $t = 8$.

Find the distance OX. [9]

3. Nov/2023/Paper_9709/42/No.5

A particle A of mass 0.5 kg is projected vertically upwards from horizontal ground with speed 25 m s^{-1}.

(a) Find the speed of A when it reaches a height of 20 m above the ground. [2]

When A reaches a height of 20 m, it collides with a particle B of mass 0.3 kg which is moving downwards in the same vertical line as A with speed 32.5 m s^{-1}. In the collision between the two particles, B is brought to instantaneous rest.

(b) Show that the velocity of A immediately after the collision is 4.5 m s^{-1} downwards. [2]

(c) Find the time interval between A and B reaching the ground. You should assume that A does not bounce when it reaches the ground. [4]

4. Nov/2023/Paper_9709/42/No.7

A particle X travels in a straight line. The velocity of X at time t s after leaving a fixed point O is denoted by v m s^{-1}, where

$$v = -0.1t^3 + 1.8t^2 - 6t + 5.6.$$

The acceleration of X is zero at $t = p$ and $t = q$, where $p < q$.

(a) Find the value of p and the value of q. [4]

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It is given that the velocity of X is zero at $t = 14$.

(b) Find the velocities of X at $t = p$ and at $t = q$, and hence sketch the velocity-time graph for the motion of X for $0 \leqslant t \leqslant 15$. [3]

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(c) Find the total distance travelled by X between $t = 0$ and $t = 15$. [5]

5. Nov/2023/Paper_9709/43/No.1

A particle is projected vertically upwards from horizontal ground with a speed of u m s^{-1}. The particle has height s m above the ground at times 3 seconds and 4 seconds after projection.

Find the value of u and the value of s. [3]

6. Nov/2023/Paper_9709/43/No.6

A particle moves in a straight line. At time t s, the acceleration, a m s^{-2}, of the particle is given by $a = 36 - 6t$. The velocity of the particle is 27 m s^{-1} when $t = 2$.

(a) Find the values of t when the particle is at instantaneous rest. [4]

(b) Find the total distance the particle travels during the first 12 seconds. [4]

7. March/2023/Paper_9709/42/No.2

A particle P is projected vertically upwards from horizontal ground with speed $15\,\text{m}\,\text{s}^{-1}$.

(a) Find the speed of P when it is 10 m above the ground. [2]

At the same instant that P is projected, a second particle Q is dropped from a height of 18 m above the ground in the same vertical line as P.

(b) Find the height above the ground at which the two particles collide. [3]

8. March/2023/Paper_9709/42/No.3

A particle moves in a straight line starting from rest from a point O. The acceleration of the particle at time t s after leaving O is a m s^{-2}, where $a = 4t^{\frac{1}{2}}$.

(a) Find the speed of the particle when $t = 9$. [2]

(b) Find the time after leaving O at which the speed (in metres per second) and the distance travelled (in metres) are numerically equal. [3]