Cambridge International AS & A Level

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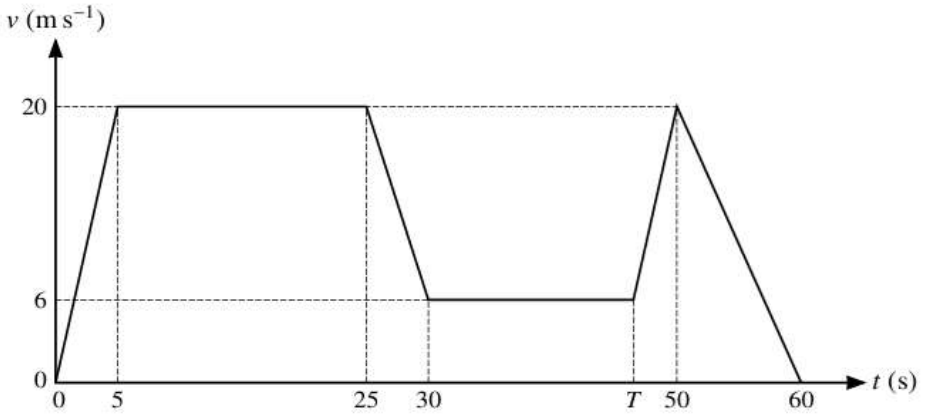
Mathematics 9709/42

Paper 4 Mechanics October/November 2021

Question No (1)

1



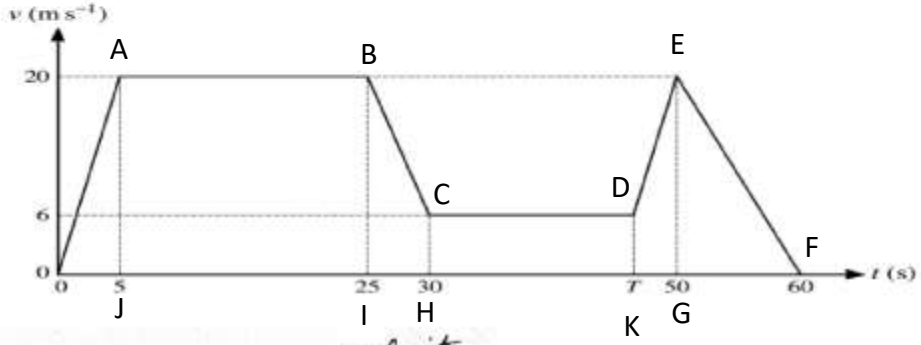
The diagram shows a velocity-time graph which models the motion of a car. The graph consists of six straight line segments. The car accelerates from rest to a speed of $20\,\text{m s}^{-1}$ over a period of 5 s, and then travels at this speed for a further 20 s. The car then decelerates to a speed of $6\,\text{m s}^{-1}$ over a period of 5 s. This speed is maintained for a further $(T - 30)$ s. The car then accelerates again to a speed of $20\,\text{m s}^{-1}$ over a period of $(50 - T)$ s, before decelerating to rest over a period of 10 s.

(a) Given that during the two stages of the motion when the car is accelerating, the accelerations are equal, find the value of T.

(b) Find the total distance travelled by the car during the motion.

Solution:

(c) OA line shows the acceleration during the first stage



$$\text{Acceleration} = \frac{\text{velocity}}{\text{time}}$$

$$= \frac{OA}{OJ}$$

$$= \frac{20}{5}$$

$$a = 4 \ m\,s^{-2}$$

DE line shows the acceleration during 2nd stage

$$\text{acceleration} = \frac{\text{velocity}}{\text{time}}$$

$$= \frac{DE}{KG}$$

$$a = \frac{14}{50 - T}$$

As the acceleration of both stage equal

$$\Rightarrow 4 = \frac{14}{50 - T}$$

$$50 - T = \frac{14}{4}$$

$$T = 50 - \frac{14}{4}$$

$$= \frac{200 - 14}{4}$$

$$T = 46.5 \text{ s}$$

(b)

Distance from 0 to 25 sec = Area of Trapezium OABI

$= \frac{1}{2}$ (sum of parallel sides) × height

$= \frac{1}{2}(|OI| + |AB|) \times BI$

$= \frac{1}{2}(25 + 20) \times 20$

$= \frac{1}{2}(45) \times 20$

$d_1 = 450$ m

Distance from 25 to 30 = Area of trapezium IBCH

$= \frac{1}{2}(6 + 20)(5)$

$= \frac{1}{2}(26)(5)$

$d_2 = 65$ m

Distance from 30 to 46.5 sec = Area of Rectangle CDHG

$= |CD| \times |CH|$

$= (46.5 - 30) \times 6$

$d_3 = 99$ m

Distance from 46.5 to 50 sec = Area of trapezium KDEG

$= \frac{1}{2}$ (sum of parallel sides) × height

$= \frac{1}{2}(|KD| + |GE|) \times |KG|$

$= \frac{1}{2}(6 + 20)(50 - 46.5)$

$= \frac{1}{2}(26)(3.5)$

$d_4 = 45.5$ m

Distance from 50 to 60 sec = Area of triangle EGF

$= \frac{1}{2}$ base × height

$= \frac{1}{2} |GF| \times |EG|$

$= \frac{1}{2}(10)(20)$

$d_5 = 100$ m

∴ total distance $= d_1 + d_2 + d_3 + d_4 + d_5$

$= 450 + 65 + 99 + 45.5 + 100$

$= 759.5$ m