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Problem 4: Two trains A and B leave the same station on parallel lines. Train A starts with uniform acceleration of $1 / 6 \mathrm{~m} / \mathrm{sec}^{2}$ and attains a speed of $24 \mathrm{Km} / \mathrm{hr}$ when a stream is reached to keep the speed constant. Train B leaves 40 seconds after with uniform acceleration of $\frac{1}{3} \mathrm{~m} / \mathrm{sec}^{2}$ and attains a maximum speed of $48 \mathrm{Km} / \mathrm{hr}$. When will B over take A.

## Solution:

Acceleration of train $\mathrm{A}, \mathrm{a}_{\mathrm{A}}=\frac{1}{6}\left(\frac{\mathrm{~m}}{\mathrm{~s}^{2}}\right)$
Max-velocity of train $\mathrm{A}, \mathrm{V}_{\mathrm{A}}=24 \mathrm{kmph}$

$$
\begin{aligned}
= & 24 \times\left(\frac{5}{18}\right) \mathrm{m} / \mathrm{s} \\
& =6.667 \mathrm{~m} / \mathrm{sec}
\end{aligned}
$$

Acceleration of train $B, a_{B}=\frac{1}{3}\left(\frac{\mathrm{~m}}{\mathrm{~s}^{2}}\right)$
Max-velocity of train $B, V_{B}=48 \mathrm{~km} / \mathrm{phr}$

$$
\begin{gathered}
=48 \times\left(\frac{5}{18}\right) \mathrm{m} / \mathrm{s} \\
\mathrm{~V}_{\mathrm{B}}=13.33 \mathrm{~m} / \mathrm{sec}
\end{gathered}
$$

Let $\mathrm{t}_{\mathrm{A}}=$ Time taken by train A to attain its max speed
$t_{B}=$ Time taken by train $B$ to attain its max. speed
$\mathrm{T}=$ Time when train B will overtake train A from its start
We know that
Acceleration, $\mathrm{a}=$ =velocity $/$ time $=\mathrm{V} / \mathrm{t}$
From that $\mathrm{t}=\frac{\mathrm{v}}{\mathrm{a}}$
For train $\mathrm{A}, \mathrm{t}_{\mathrm{A}}=\frac{\mathrm{V}_{\mathrm{A}}}{\mathrm{a}_{\mathrm{A}}}=\frac{6.667}{\left(\frac{1}{6}\right)}=40 \mathrm{sec}$
For train $B, t_{B}=\frac{V_{B}}{a_{B}}=\frac{13.334}{\left(\frac{1}{3}\right)}=40 \mathrm{sec}$
Distance travelled by train A before attaining the max. speed

$$
\mathrm{S}_{\mathrm{A} 1}=\mathrm{u}_{\mathrm{A}} \mathrm{t}_{\mathrm{A}}+\frac{1}{2} \mathrm{a}_{\mathrm{A}} \mathrm{t}_{\mathrm{A}}^{2}
$$

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$$
\begin{gathered}
=0+\frac{1}{2}\left(\frac{1}{6}\right)(40)^{2} \\
\mathrm{~S}_{\mathrm{A} 1}=133.33 \mathrm{~m}
\end{gathered}
$$

Distance travelled by train B before attaining the max. speed

$$
\begin{gathered}
\mathrm{S}_{\mathrm{B} 1}=\mathrm{u}_{\mathrm{B}} \mathrm{t}_{\mathrm{B}}+\frac{1}{2} \mathrm{a}_{\mathrm{B}} \mathrm{t}_{\mathrm{B}}^{2} \\
=0+\frac{1}{2}\left(\frac{1}{3}\right)(40)^{2} \\
\mathrm{~S}_{\mathrm{B} 1}=266.67 \mathrm{~m}
\end{gathered}
$$

From the given data we know train A has travelled for $(\mathrm{T}+40)$ sec.
Distance travelled by train A before attaining the max. speed

$$
\begin{gathered}
\mathrm{S}_{\mathrm{A} 2}=\mathrm{V}_{\mathrm{A}} \times \text { time } \\
=6.667 \times\left(\mathrm{T}+40-\mathrm{t}_{\mathrm{A}}\right) \\
\mathrm{S}_{\mathrm{A} 2}=6.667 \mathrm{Tm}
\end{gathered}
$$

Distance travelled by train B before attaining the maximum speed

$$
\begin{gathered}
\mathrm{S}_{\mathrm{B} 2}=\mathrm{V}_{\mathrm{B}} \times \text { time } \\
=13.33 \times(\mathrm{T}-40)=13.33 \mathrm{~T}-533.2
\end{gathered}
$$

For the train B to overtake the train A

$$
\begin{gathered}
\mathrm{S}_{\mathrm{A} 1}+\mathrm{S}_{\mathrm{A} 2}=\mathrm{S}_{\mathrm{B} 1}+\mathrm{S}_{\mathrm{B} 2} \\
133.33+6.667 \mathrm{~T}=13.33 \mathrm{~T}-533.2 \\
\mathrm{~T}=100 \mathrm{sec}
\end{gathered}
$$

