Solving Problems Involving Linear Equations – Distance, Speed, and Time

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What are Motion-related Problems?

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What are Motion-related Problems?

Problems that make use of the formula $d = ax + b$, where

- d = distance
- a = constant rate the object is moving per unit time
- x = time the object has moved
- b = initial distance

How to Solve Motion-related Problems Involving Linear Equations?

1. Read, understand, and analyze the problem.

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2. Use the facts of the problem to form a working equation.

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3. Solve the equation.

Example 1

Eugene was engaged in reading his favorite Manga while going to his 5th class. Unknowingly, Jenny who is 50 meters away coming from the opposite direction is also reading her report for her next class. If the distance between them is gradually getting smaller by one meter per second, how long will it take before they bump into each other?

How to Solve Motion-related Problems Involving Linear Equations?

1. Read, understand, and analyze the problem.

Example 1

Eugene was engaged in reading his favorite Manga while going to his 5th class. Unknowingly, Jenny who is 50 meters away coming from the opposite direction is also reading her report for her next class. If the distance between them is gradually getting smaller by one meter per second, how long will it take before they bump into each other?

Given:

Example 1

Eugene was engaged in reading his favorite Manga while going to his 5th class. Unknowingly, Jenny who is 50 meters away coming from the opposite direction is also reading her report for her next class. If the distance between them is gradually getting smaller by one meter per second, how long will it take before they bump into each other?

Given: $b \;=\; 50\text{ m.}$

Example 1

Eugene was engaged in reading his favorite Manga while going to his 5th class. Unknowingly, Jenny who is 50 meters away coming from the opposite direction is also reading her report for her next class. If the distance between them is gradually getting smaller by one meter per second, how long will it take before they bump into each other?

$$\text{Given:} \quad \begin{aligned} b &= 50\,\text{m.} \\ a &= -1\tfrac{m}{s} \end{aligned}$$

Example 1

Eugene was engaged in reading his favorite Manga while going to his 5th class. Unknowingly, Jenny who is 50 meters away coming from the opposite direction is also reading her report for her next class. If the distance between them is gradually getting smaller by one meter per second, how long will it take before they bump into each other?

$$\text{Given:} \quad \begin{aligned} b &= 50\text{ m.} \\ a &= -1\frac{m}{s} \\ d &= 0\text{ m.} \end{aligned}$$

Example 1

Eugene was engaged in reading his favorite Manga while going to his 5th class. Unknowingly, Jenny who is 50 meters away coming from the opposite direction is also reading her report for her next class. If the distance between them is gradually getting smaller by one meter per second, how long will it take before they bump into each other?

$$
\begin{array}{llcl}
\text{Given:} & b & = & 50 \text{ m.} \\
 & a & = & -1\frac{m}{s} \\
 & d & = & 0 \text{ m.} \\
\text{Find:} & x & = & \text{time before they bump}
\end{array}
$$

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\begin{array}{llcl}
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$$\begin{array}{llcl} \text{Given:} & b & = & 50 \text{ m.} \\ & a & = & -1\frac{m}{s} \\ & d & = & 0 \text{ m.} \\ \text{Find:} & x & = & \text{time before they bump} \end{array}$$

$d = ax + b$

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$$\begin{array}{llll} \text{Given:} & b & = & 50\text{ m.} \\ & a & = & -1\frac{m}{s} \\ & d & = & 0\text{ m.} \\ \text{Find:} & x & = & \text{time before they bump} \end{array}$$

$$d = ax + b$$

$$0m =$$

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$$\begin{array}{lrcl} \text{Given:} & b & = & 50 \text{ m.} \\ & a & = & -1\frac{m}{s} \\ & d & = & 0 \text{ m.} \\ \text{Find:} & x & = & \text{time before they bump} \end{array}$$

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$$0m = \left(-1\frac{m}{s}\right)$$

Example 1

$$\begin{aligned}
\text{Given:}\quad b &= 50\text{ m.}\\
a &= -1\tfrac{m}{s}\\
d &= 0\text{ m.}\\
\text{Find:}\quad x &= \text{time before they bump}
\end{aligned}$$

$$d = ax + b$$

$$0m = \left(-1\tfrac{m}{s}\right)x$$

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$$\begin{array}{llcl} \text{Given:} & b & = & 50 \text{ m.} \\ & a & = & -1\frac{m}{s} \\ & d & = & 0 \text{ m.} \\ \text{Find:} & x & = & \text{time before they bump} \end{array}$$

$$d = ax + b$$

$$0m = \left(-1\frac{m}{s}\right)x + 50m$$

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$d = ax + b$

$0m = \left(-1\frac{m}{s}\right)x + 50m$ Substitution Property

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\begin{array}{lcll}
\text{Given:} & b & = & 50 \text{ m.} \\
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\end{array}
$$

$d = ax + b$

$0m = \left(-1\frac{m}{s}\right)x + 50m$ Substitution Property

$\therefore$ the working equation is
$0m = \left(-1\frac{m}{s}\right)x + 50m.$

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1. Read, understand, and analyze the problem.
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Example 1

Solve the equation $0m = \left(-1\frac{m}{s}\right)x + 50m$.

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$$-50m = \left(-1\frac{m}{s}\right)x$$

Example 1

Solve the equation $0m = \left(-1\frac{m}{s}\right)x + 50m$.

$$0m - 50m = \left(-1\frac{m}{s}\right)x + 50m - 50m$$

$$-50m = \left(-1\frac{m}{s}\right)x$$

$$\frac{-50m}{-1\frac{m}{s}} = \frac{\left(-1\frac{m}{s}\right)x}{-1\frac{m}{s}}$$

Example 1

Solve the equation $0m = \left(-1\frac{m}{s}\right)x + 50m$.

$$0m - 50m = \left(-1\frac{m}{s}\right)x + 50m - 50m$$

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$$50s = x$$

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Solve the equation $0m = \left(-1\frac{m}{s}\right)x + 50m$.

$$0m - 50m = \left(-1\frac{m}{s}\right)x + 50m - 50m$$

$$-50m = \left(-1\frac{m}{s}\right)x$$

$$\frac{-50m}{-1\frac{m}{s}} = \frac{\left(-1\frac{m}{s}\right)x}{-1\frac{m}{s}}$$

$$50s = x$$

$\therefore$ the time before they bump is 50 seconds.

Example 2

The distance between two towns is 380 km. At the same moment, a passenger car and a truck start moving towards each other from different towns. They meet 4 hours later. If the car drives 5 kph faster than the truck, what are their speeds in kilometers per hour?

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Given: $b = 380$ km.

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$$\begin{aligned} b &= 380 \text{ km.} \\ d &= 0 \text{ km.} \\ x &= 4h \end{aligned}$$

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 & a_c & = & a_t + 5 \text{ kph}
\end{array}
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 & x & = & 4h \\
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 & a_c & = & a_t + 5\text{ kph} \\
 & a & = & -(a_t + a_c) = -(2a_t + 5)\text{ kph} \\
 & & = & -2a_t - 5\text{ kph}
\end{array}
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\text{Find:} & & &
\end{array}$$

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\text{Find:} & a_t & = & \text{speed of truck}
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\text{Given:} & b & = & 380\text{ km.} \\
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 & a_c & = & a_t + 5\text{ kph} \\
 & a & = & -(a_t + a_c) = -(2a_t + 5)\text{ kph} \\
 & & = & -2a_t - 5\text{ kph} \\
\text{Find:} & a_t & = & \text{speed of truck} \\
 & a_c & = & \text{speed of car}
\end{array}
$$

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\begin{array}{llcl}
\text{Given:} & b & = & 380\ \text{km.} \\
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$$\begin{array}{llcl} \text{Given:} & b & = & 380 \text{ km.} \\ & d & = & 0 \text{ km.} \\ & x & = & 4h \\ \text{Let:} & a_t & = & a_t \text{ kph} \\ & a_c & = & a_t + 5 \text{ kph} \\ & a & = & -2a_t - 5 \text{ kph} \end{array}$$

$$d = ax + b$$

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\begin{aligned}
\text{Given:}\quad b &= 380 \text{ km.}\\
d &= 0 \text{ km.}\\
x &= 4h\\
\text{Let:}\quad a_t &= a_t \text{ kph}\\
a_c &= a_t + 5 \text{ kph}\\
a &= -2a_t - 5 \text{ kph}
\end{aligned}
$$

$$d = ax + b$$

$$0km =$$

Example 2

$$\begin{array}{llll} \text{Given:} & b & = & 380 \text{ km.} \\ & d & = & 0 \text{ km.} \\ & x & = & 4h \\ \text{Let:} & a_t & = & a_t \text{ kph} \\ & a_c & = & a_t + 5 \text{ kph} \\ & a & = & -2a_t - 5 \text{ kph} \end{array}$$

$$d = ax + b$$

$$0km = (-2a_t - 5kph)$$

Example 2

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\begin{aligned}
\text{Given:}\quad b &= 380 \text{ km.} \\
d &= 0 \text{ km.} \\
x &= 4h \\
\text{Let:}\quad a_t &= a_t \text{ kph} \\
a_c &= a_t + 5 \text{ kph} \\
a &= -2a_t - 5 \text{ kph}
\end{aligned}
$$

$$d = ax + b$$

$$0km = (-2a_t - 5kph)(4h)$$

Example 2

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\text{Given:} & b & = & 380 \text{ km.} \\
& d & = & 0 \text{ km.} \\
& x & = & 4h \\
\text{Let:} & a_t & = & a_t \text{ kph} \\
& a_c & = & a_t + 5 \text{ kph} \\
& a & = & -2a_t - 5 \text{ kph}
\end{array}
$$

$$d = ax + b$$

$$0km = (-2a_t - 5kph)(4h) + 380km$$

Example 2

$$\begin{array}{llll} \text{Given:} & b & = & 380 \text{ km.} \\ & d & = & 0 \text{ km.} \\ & x & = & 4h \\ \text{Let:} & a_t & = & a_t \text{ kph} \\ & a_c & = & a_t + 5 \text{ kph} \\ & a & = & -2a_t - 5 \text{ kph} \end{array}$$

$$d = ax + b$$

$$0km = (-2a_t - 5kph)(4h) + 380km$$

$\therefore$ the working equation is
$0km = (-2a_t - 5kph)(4h) + 380km.$

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1. Read, understand, and analyze the problem.
2. Use the facts of the problem to form a working equation.
3. Solve the equation.

Example 2

Solve the equation $0km = (-2a_t - 5kph)(4h) + 380km$.

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Solve the equation $0km = (-2a_t - 5kph)(4h) + 380km$.

$$0km - 380km = (-2a_t - 5kph)(4h) + 380km - 380km$$

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$$0km - 380km = (-2a_t - 5kph)(4h) + 380km - 380km$$

$$-380km = (-2a_t - 5kph)(4h)$$

Example 2

Solve the equation $0km = (-2a_t - 5kph)(4h) + 380km$.

$$0km - 380km = (-2a_t - 5kph)(4h) + 380km - 380km$$

$$-380km = (-2a_t - 5kph)(4h)$$

$$\frac{-380km}{(4h)} = \frac{(-2a_t - 5kph)(4h)}{(4h)}$$

Example 2

Solve the equation $0km = (-2a_t - 5kph)(4h) + 380km$.

$$0km - 380km = (-2a_t - 5kph)(4h) + 380km - 380km$$

$$-380km = (-2a_t - 5kph)(4h)$$

$$\frac{-380km}{(4h)} = \frac{(-2a_t - 5kph)(4h)}{(4h)}$$

$$-95kph = -2a_t - 5kph$$

Example 2

Solve the equation $0km = (-2a_t - 5kph)(4h) + 380km$.

$$0km - 380km = (-2a_t - 5kph)(4h) + 380km - 380km$$

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$$\frac{-380km}{(4h)} = \frac{(-2a_t - 5kph)(4h)}{(4h)}$$

$$-95kph = -2a_t - 5kph$$

$$-95kph + 5kph = -2a_t - 5kph + 5kph$$

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Solve the equation $0km = (-2a_t - 5kph)(4h) + 380km$.

$$0km - 380km = (-2a_t - 5kph)(4h) + 380km - 380km$$

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$$-95kph = -2a_t - 5kph$$

$$-95kph + 5kph = -2a_t - 5kph + 5kph$$

$$-90kph = -2a_t$$

Example 2

Solve the equation $0km = (-2a_t - 5kph)(4h) + 380km$.

$$0km - 380km = (-2a_t - 5kph)(4h) + 380km - 380km$$

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$$\frac{-380km}{(4h)} = \frac{(-2a_t - 5kph)(4h)}{(4h)}$$

$$-95kph = -2a_t - 5kph$$

$$-95kph + 5kph = -2a_t - 5kph + 5kph$$

$$-90kph = -2a_t$$

$$\frac{-90}{-2}kph = \frac{-2a_t}{-2}$$

Example 2

Solve the equation $0km = (-2a_t - 5kph)(4h) + 380km$.

$$0km - 380km = (-2a_t - 5kph)(4h) + 380km - 380km$$

$$-380km = (-2a_t - 5kph)(4h)$$

$$\frac{-380km}{(4h)} = \frac{(-2a_t - 5kph)(4h)}{(4h)}$$

$$-95kph = -2a_t - 5kph$$

$$-95kph + 5kph = -2a_t - 5kph + 5kph$$

$$-90kph = -2a_t$$

$$\frac{-90}{-2}kph = \frac{-2a_t}{-2}$$

$45kph = a_t$ $\therefore$ the truck's speed is 45 kph

Example 2

Find the car's speed.

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$a_c = a_t + 5 \text{ kph}$

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$$a_c = a_t + 5 \text{ kph}$$

$$a_c = 45 + 5 \text{ kph}$$

Example 2

Find the car's speed.

$a_c = a_t + 5$ kph

$a_c = 45 + 5$ kph Substitution

Example 2

Find the car's speed.

$$a_c = a_t + 5 \text{ kph}$$

$$a_c = 45 + 5 \text{ kph} \quad \text{Substitution}$$

$$a_c = 50 \text{ kph}$$

Example 2

Find the car's speed.

$$a_c = a_t + 5 \text{ kph}$$

$$a_c = 45 + 5 \text{ kph} \qquad \text{Substitution}$$

$$a_c = 50 \text{ kph} \qquad \text{Simplification}$$

$\therefore$ the car's speed is 50 kph.

Example 3

Two trains start from the same station at the same time, train A is going north bound while train B is going south bound. After 5 minutes the trains are 10km apart, in 15 minutes they are 30km apart. How many minutes will it take for the trains to be 50km apart?

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1. Read, understand, and analyze the problem.

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Two trains start from the same station at the same time, train A is going north bound while train B is going south bound. After 5 minutes the trains are 10km apart, in 15 minutes they are 30km apart. How many minutes will it take for the trains to be 50km apart?

Given:

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Two trains start from the same station at the same time, train A is going north bound while train B is going south bound. After 5 minutes the trains are 10km apart, in 15 minutes they are 30km apart. How many minutes will it take for the trains to be 50km apart?

Given: $b = 0$ km.

Example 3

Two trains start from the same station at the same time, train A is going north bound while train B is going south bound. After 5 minutes the trains are 10km apart, in 15 minutes they are 30km apart. How many minutes will it take for the trains to be 50km apart?

$$\text{Given:} \quad \begin{aligned} b &= 0 \text{ km.} \\ a_1 &= \frac{10km}{5min} \end{aligned}$$

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Two trains start from the same station at the same time, train A is going north bound while train B is going south bound. After 5 minutes the trains are 10km apart, in 15 minutes they are 30km apart. How many minutes will it take for the trains to be 50km apart?

$$\begin{aligned} \text{Given:} \quad b &= 0\text{ km.} \\ a_1 &= \frac{10km}{5min} \\ a_2 &= \frac{30km}{15min} \end{aligned}$$

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$$\text{Given:} \quad \begin{aligned} b &= 0 \text{ km.} \\ a_1 &= \frac{10km}{5min} \\ a_2 &= \frac{30km}{15min} \\ a &= \frac{2km}{min} \end{aligned}$$

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Two trains start from the same station at the same time, train A is going north bound while train B is going south bound. After 5 minutes the trains are 10km apart, in 15 minutes they are 30km apart. How many minutes will it take for the trains to be 50km apart?

$$\text{Given:}\quad \begin{aligned} b &= 0 \text{ km.} \\ a_1 &= \frac{10km}{5min} \\ a_2 &= \frac{30km}{15min} \\ a &= \frac{2km}{min} \\ d &= 50 \text{ km.} \end{aligned}$$

Example 3

Two trains start from the same station at the same time, train A is going north bound while train B is going south bound. After 5 minutes the trains are 10km apart, in 15 minutes they are 30km apart. How many minutes will it take for the trains to be 50km apart?

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\begin{array}{llcl}
\text{Given:} & b & = & 0 \text{ km.} \\
 & a_1 & = & \frac{10km}{5min} \\
 & a_2 & = & \frac{30km}{15min} \\
 & a & = & \frac{2km}{min} \\
 & d & = & 50 \text{ km.} \\
\text{Find:} & x & = & \text{time to be 50 km apart}
\end{array}
$$

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1. Read, understand, and analyze the problem.
2. Use the facts of the problem to form a working equation.

Example 3

$$\begin{array}{llcl}
\text{Given:} & b & = & 0 \text{ km.} \\
 & a_1 & = & \frac{10km}{5min} \\
 & a_2 & = & \frac{30km}{15min} \\
 & a & = & \frac{2km}{min} \\
 & d & = & 50 \text{ km.} \\
\text{Find:} & x & = & \text{time to be 50 km apart}
\end{array}$$

Example 3

$$\begin{array}{lccl} \text{Given:} & b & = & 0 \text{ km.} \\ & a_1 & = & \frac{10km}{5min} \\ & a_2 & = & \frac{30km}{15min} \\ & a & = & \frac{2km}{min} \\ & d & = & 50 \text{ km.} \\ \text{Find:} & x & = & \text{time to be 50 km apart} \end{array}$$

$d = ax + b$

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$$50km = \left(2\frac{km}{min}\right)x$$

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$50km = \left(2\frac{km}{min}\right) x + 0km$ Substitution Property

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\end{array}$$

$$d = ax + b$$

$$50km = \left(2\frac{km}{min}\right)x + 0km \quad \text{Substitution Property}$$

$\therefore$ the working equation is $50km = \left(2\frac{km}{min}\right)x$.

How to Solve Motion-related Problems Involving Linear Equations?

1. Read, understand, and analyze the problem.
2. Use the facts of the problem to form a working equation.
3. Solve the equation.

Example 3

Solve the equation $50km = \left(2\frac{km}{min}\right) x$.

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$$25min = x$$

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$$25min = x \qquad \text{Simplification}$$

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$$25min = x \quad \text{Simplification}$$

$\therefore$ the time it will take for the trains to be 50km apart is 25 minutes.

Example 4

A long-distance runner started a course running at an average speed of 6 mph. One and one-half hours later, a cyclist traveled the same course at an average speed of 12 mph. How long after the runner started did the cyclist overtake the runner?

How to Solve Motion-related Problems Involving Linear Equations?

1. Read, understand, and analyze the problem.

Example 4

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Given: $a_r = 6 \text{ mph}$

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$$\text{Given:} \quad \begin{aligned} a_r &= 6\text{ mph} \\ x_r &= 1.5\text{ h} \end{aligned}$$

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$$\text{Given:}\quad \begin{aligned} a_r &= 6\text{ mph} \\ x_r &= 1.5\text{ h} \\ b &= (a_r)(x_r) = (6mph)(1.5h) = 9mi. \end{aligned}$$

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\text{Given:}\quad \begin{aligned}
a_r &= \text{6 mph} \\
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a_c &= \text{12 mph}
\end{aligned}
$$

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How to Solve Motion-related Problems Involving Linear Equations?

1. Read, understand, and analyze the problem.
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$$\begin{array}{llcl}
\text{Given:} & a_r & = & 6 \text{ mph} \\
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$$d = ax + b$$

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$$d = ax + b$$

$$0mi =$$

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\end{array}$$

$$d = ax + b$$

$$0mi = (-6mph)$$

Example 4

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$$d = ax + b$$

$$0mi = (-6mph)(x)$$

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$$d = ax + b$$

$$0mi = (-6mph)(x) + 9mi$$

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$$d = ax + b$$

$$0mi = (-6mph)(x) + 9mi \quad \text{Substitution Property}$$

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$$d = ax + b$$

$$0mi = \ (-6mph)\,(x) + 9mi \quad \text{Substitution Property}$$

$\therefore$ the working equation is
$0mi = (-6mph)(x) + 9mi.$

How to Solve Motion-related Problems Involving Linear Equations?

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Example 4

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Solve the equation $0mi = (-6mph)(x) + 9mi$.

$$0mi - 9mi = (-6mph)(x) + 9mi - 9mi$$

$$-9mi = (-6mph)(x)$$

$$\frac{-9mi}{(-6mph)} = \frac{(-6mph)(x)}{(-6mph)}$$

$$\frac{3}{2}h = x$$

$\therefore$ the time for cyclist to overtake the runner is $\frac{3}{2}$ hours or $1\frac{1}{2}$ hours or 1.5 hours.

Example 2

Find the total time after the runner started.

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$x_T = x + x_r$

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Find the total time after the runner started.

$$x_T = x + x_r$$

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$x_T = x + x_r$

$x_T = 1.5h + 1.5h$ Substitution

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$x_T = 3h$

Example 2

Find the total time after the runner started.

$$x_T = x + x_r$$

$$x_T = 1.5h + 1.5h \quad \text{Substitution}$$

$$x_T = 3h \quad \text{Simplification}$$

$\therefore$ the total time after the runner started is 3 hours.

Thank you for watching.