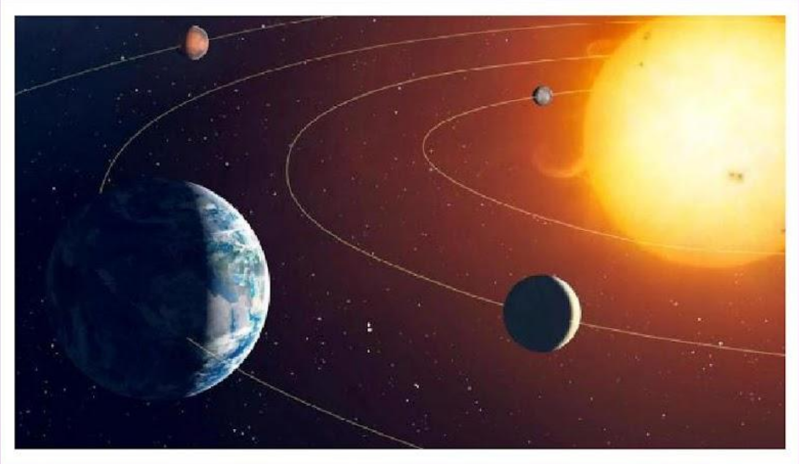
RELATIVE MOTION L-1

RELATIVE MOTION IN 1-D AND 2-D



MISSION MBBS 11^{th} | PHYSICS

Motion in 2 – Dimension

Projectile Motion

Relative Motion

Relative Motion

B

A

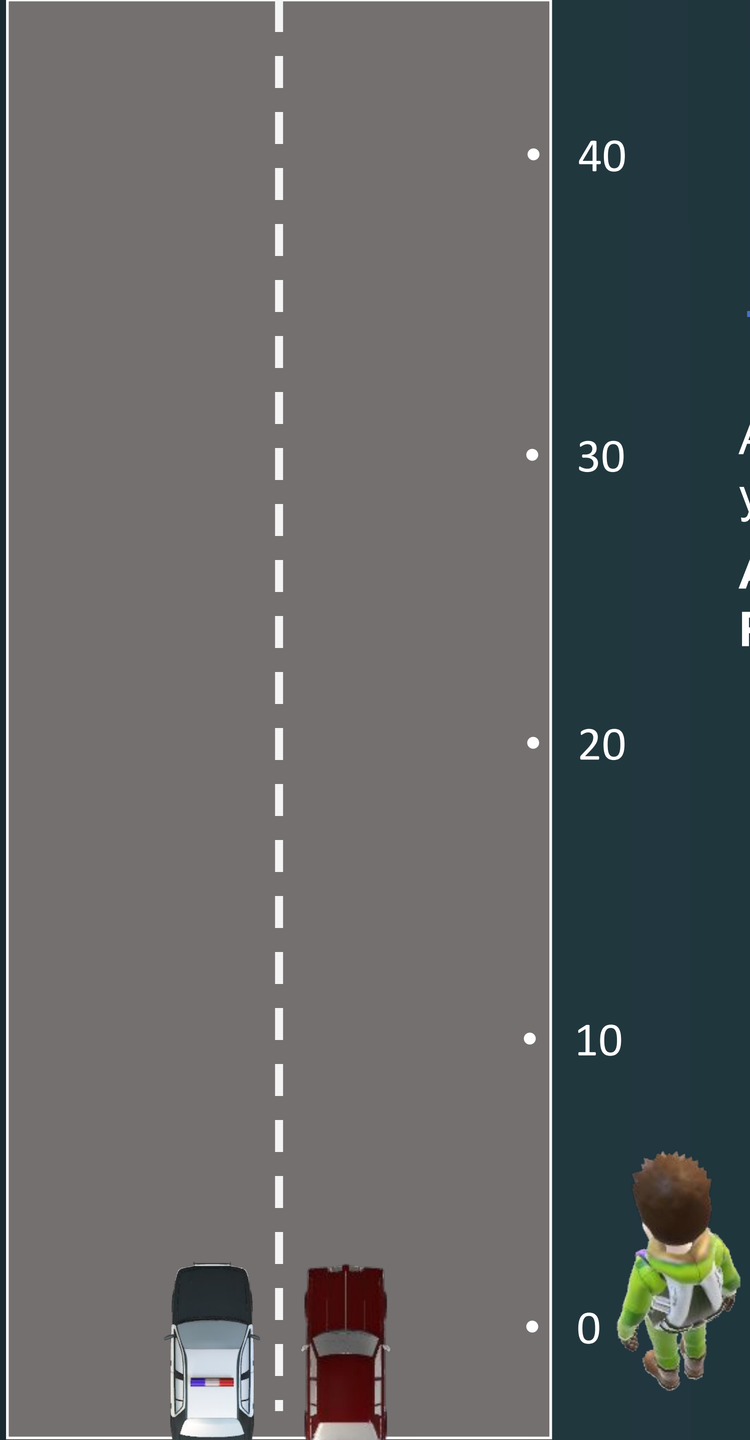
Point of View

Motion

- Motion is a combined property of the object under study as well as the observer.
- Motion is always defined with respect to an observer or reference frame.
- It is always relative, there is no such thing as absolute motion or absolute rest.

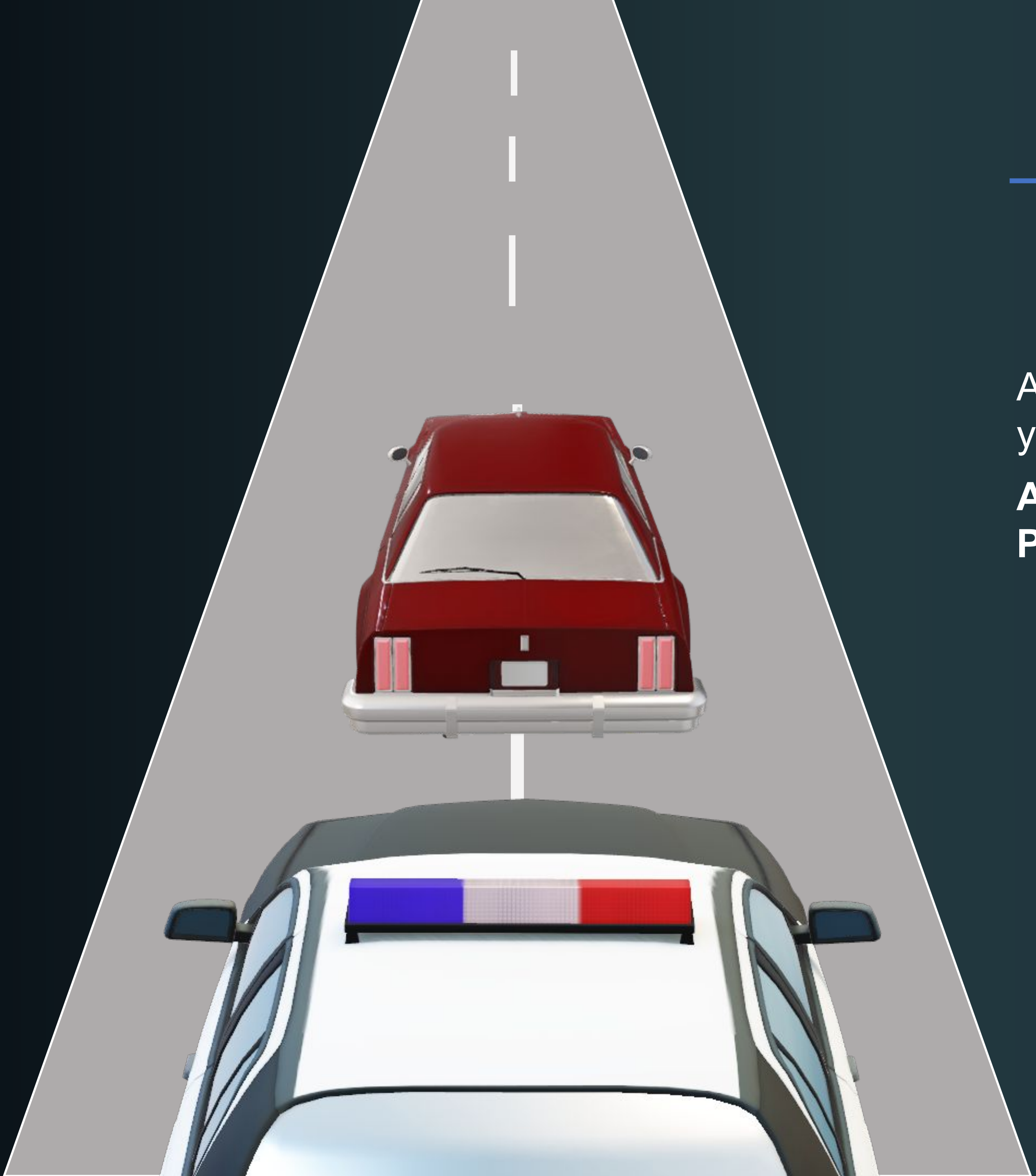
How far is the thief?

2 seconds



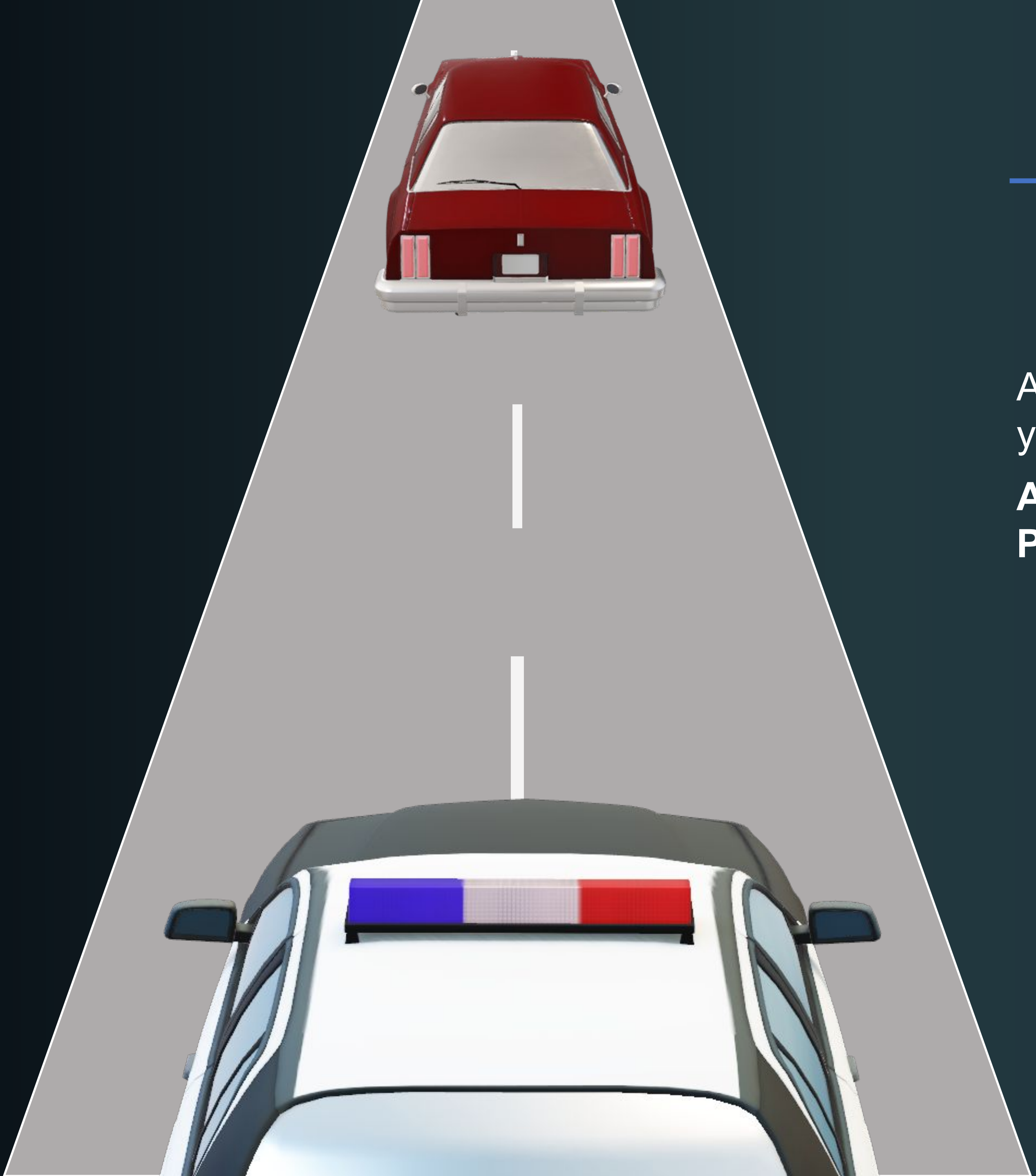
According to you

According to Police



How far is the thief?

	1s	2s
According to you	20 m	40 m
According to Police		

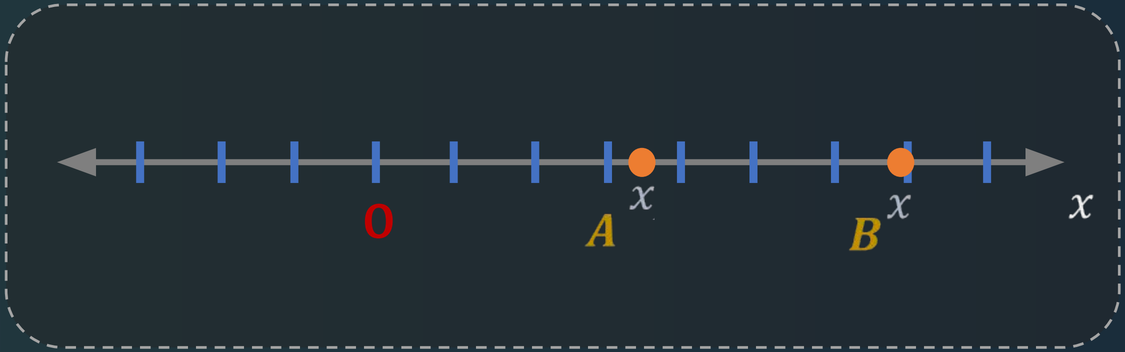


How **far** is the thief?

	1s	2s
According to you	20 m	40 m
According to Police		

Relative Motion in 1-D

Relative position: $\vec{x}_{BA} = \vec{x}_B - \vec{x}_A$

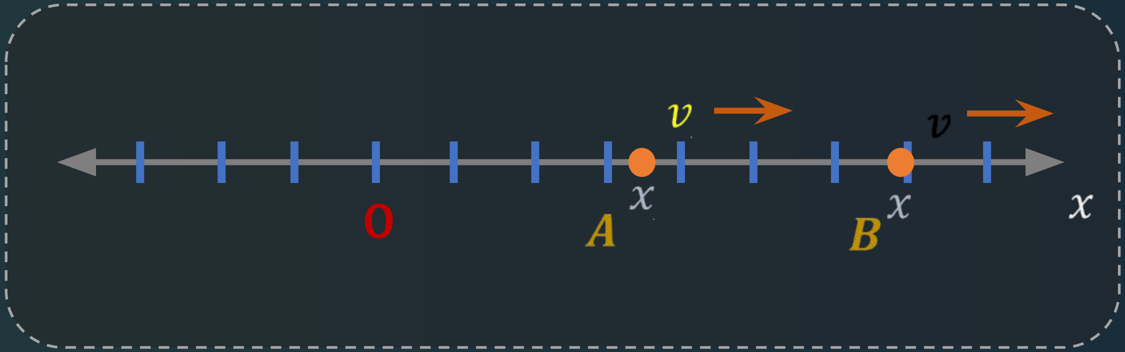


Relative Motion in 1-D

Relative position: $\vec{x}_{BA} = \vec{x}_B - \vec{x}_A$

$$\frac{d}{dt}\vec{x}_{BA} = \frac{d}{dt}\vec{x}_B - \frac{d}{dt}\vec{x}_A$$

Relative velocity: $\vec{v}_{BA} = \vec{v}_B - \vec{v}_A$



Relative Motion in 1-D

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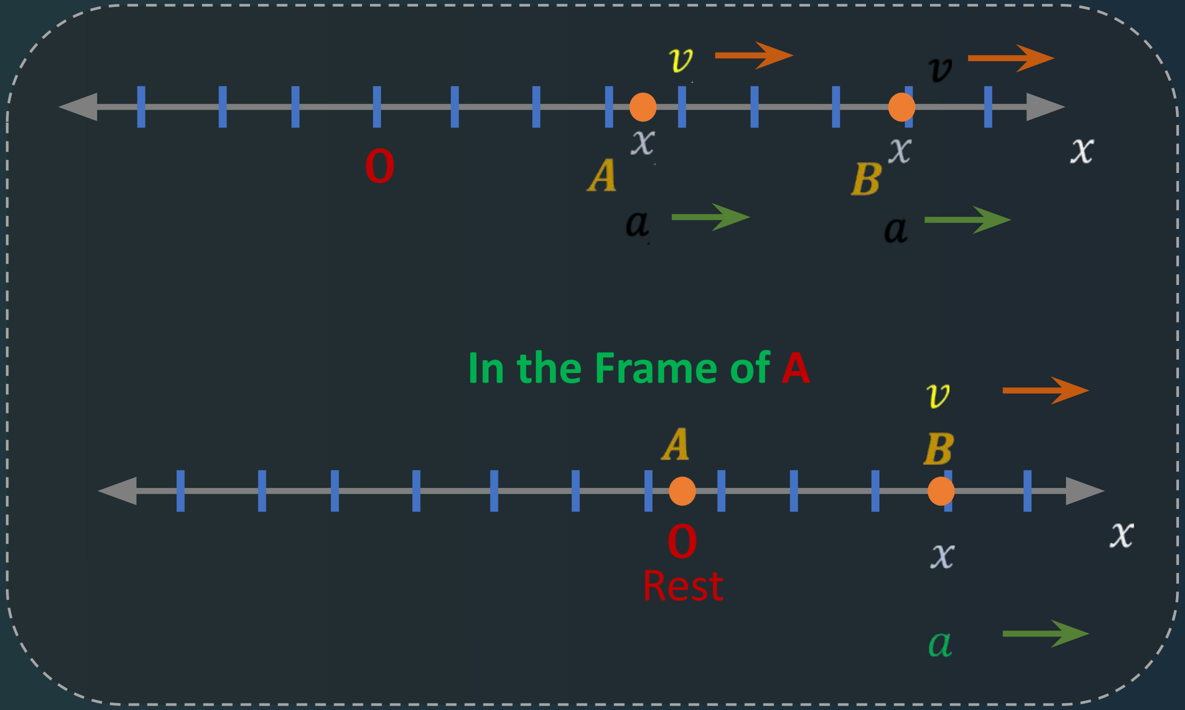
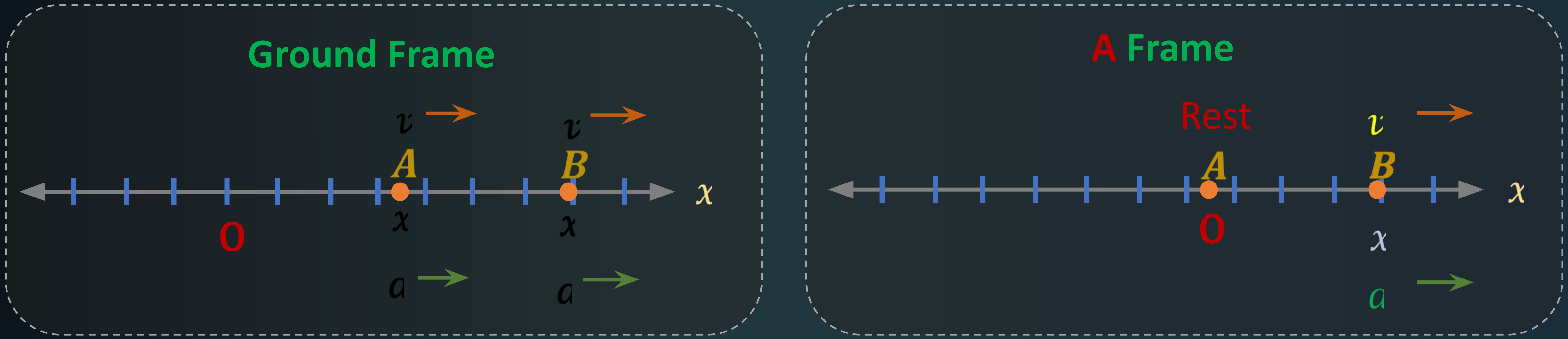
Relative velocity: $\vec{v}_{BA} = \vec{v}_B - \vec{v}_A$

$$\frac{d}{dt}\vec{v}_{BA} = \frac{d}{dt}\vec{v}_B - \frac{d}{dt}\vec{v}_A$$

Relative acceleration: $\vec{a}_{BA} = \vec{a}_B - \vec{a}_A$



Relative Motion in 1-D



With the change in frame, the origin of every parameter is recalibrated i.e. the now chosen reference frame is the **"new rest".**

Relative Motion in 1-D

Relative Position: A position defined with respect to another position, either fixed or moving.

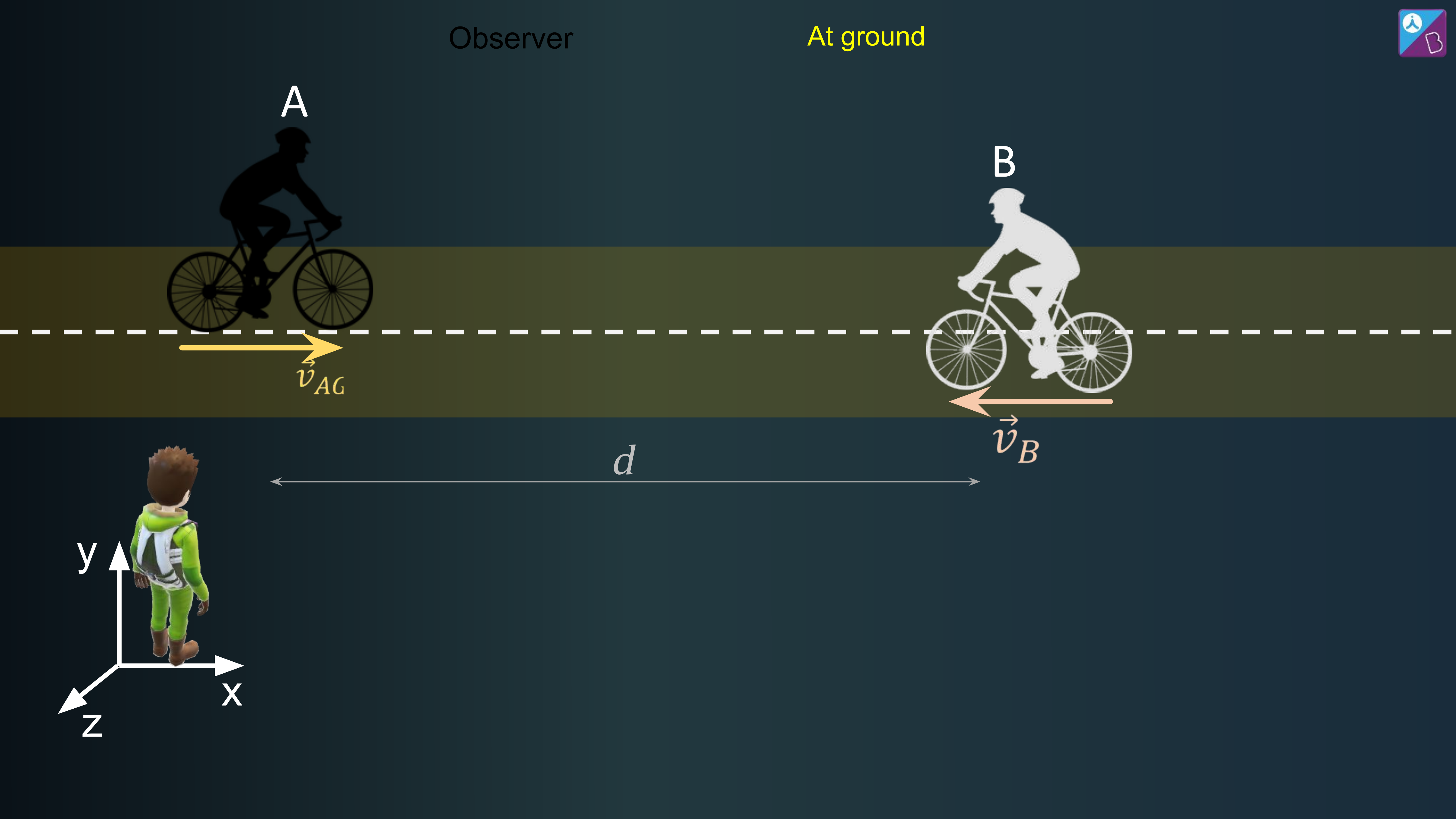
$$\vec{x}_{AB} = \vec{x}_{AG} - \vec{x}_{BG}$$

Relative velocity: The velocity with which any $\text{Object} - A$ appears to move according to an observer on any $\text{Ojbect} - B$.

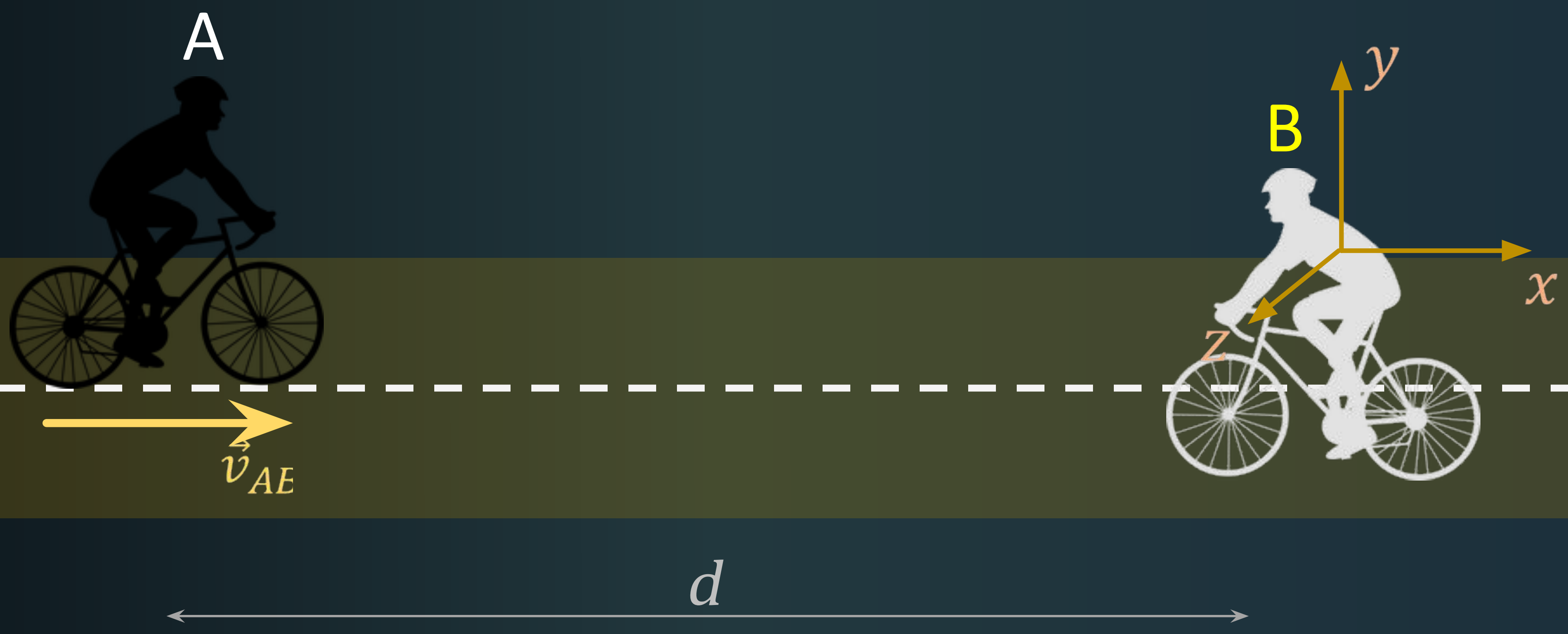
It is denoted as $\vec{v}_{AB}$.

$$\vec{v}_{AB} = \vec{v}_{AG} - \vec{v}_{BG}$$

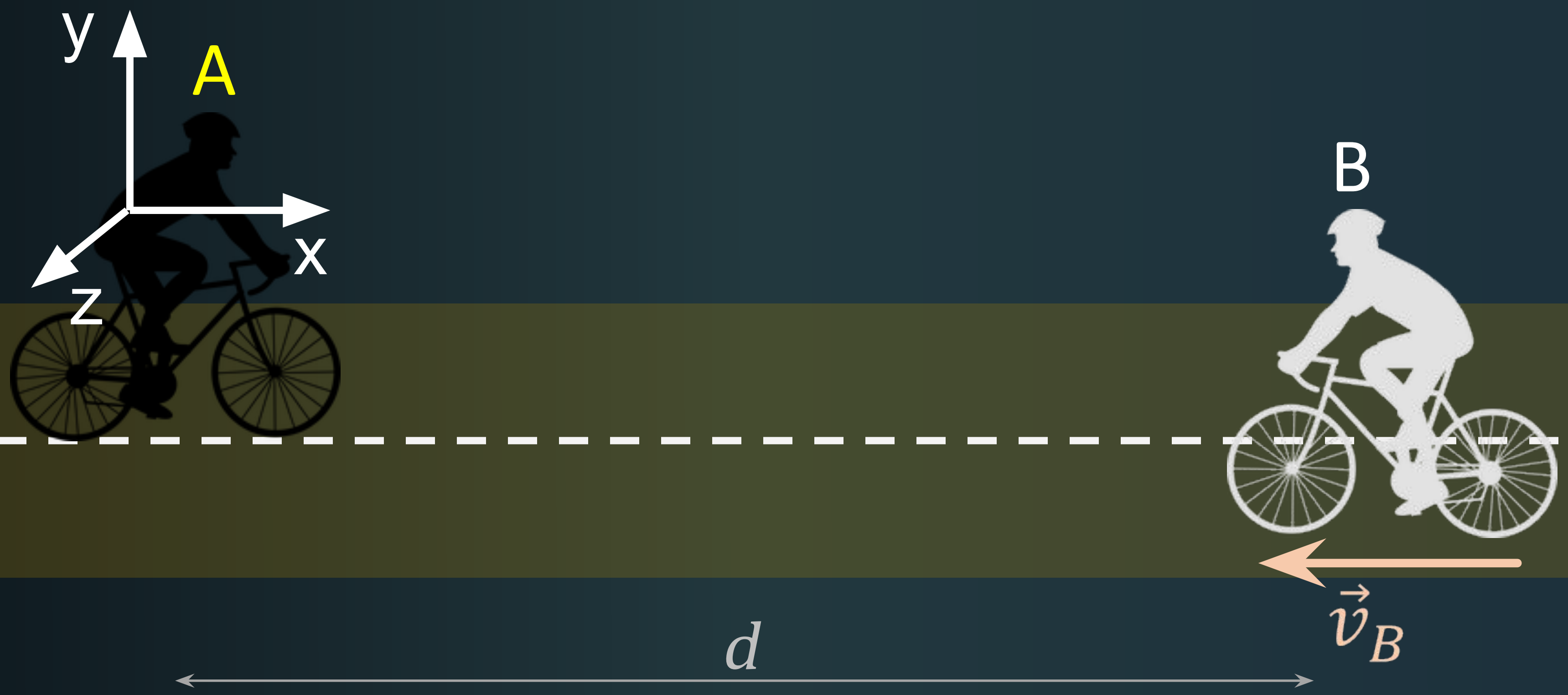
$$\vec{v}_{AB} = \vec{v}_{A} - \vec{v}_{B}$$


Observer
At ground
A
B
$\vec{v}_{AG}$
$\vec{v}_B$
d
y
x
z

Observer B



Observer A



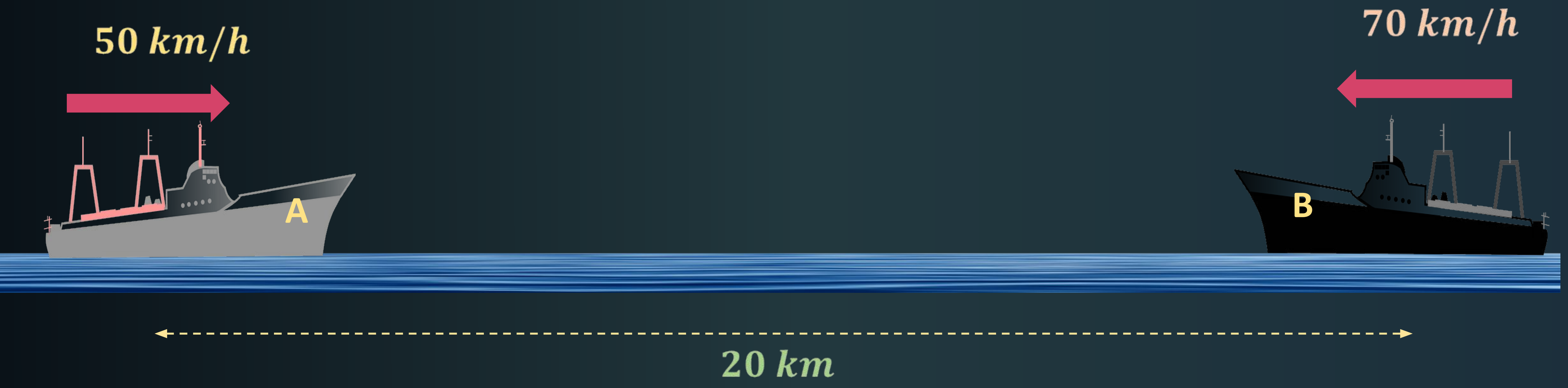
Example

Two ships $20\ km$ away start to move towards each other. Speeds of ship A and ship B are $50\ km/hr$ and $70\ km/hr$ respectively. After how much time will they cross each other?

- A $10\ min$
- B $15\ min$
- C $30\ min$
- D $20\ min$

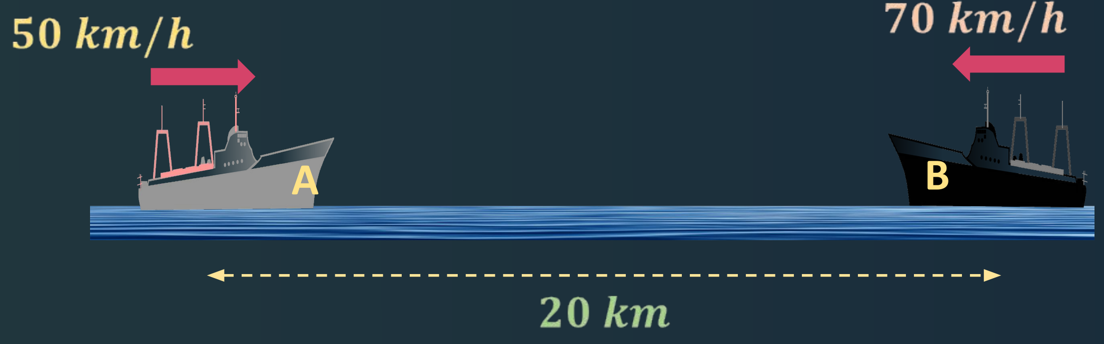
Example

Two ships $20\ km$ away start to move towards each other. Speeds of ship A and ship B are $50\ km/hr$ and $70\ km/hr$ respectively. After how much time will they cross each other?



Example

Relative Velocity: $\vec{v}_r = \vec{v}_{AB} = \vec{v}_A - \vec{v}_B$



$$\vec{v}_r = 50\ km/h(\hat{\imath}) - 70\ km/h(-\hat{\imath})$$

$$\vec{v}_r = 120\ km/h(\hat{\imath})$$

$$v_r = 120\ km/h$$

We know, $t = \frac{d}{v_r}$

$$t = \frac{20}{120}$$

$$t = \frac{20}{120} \times 60 = 10\ min$$

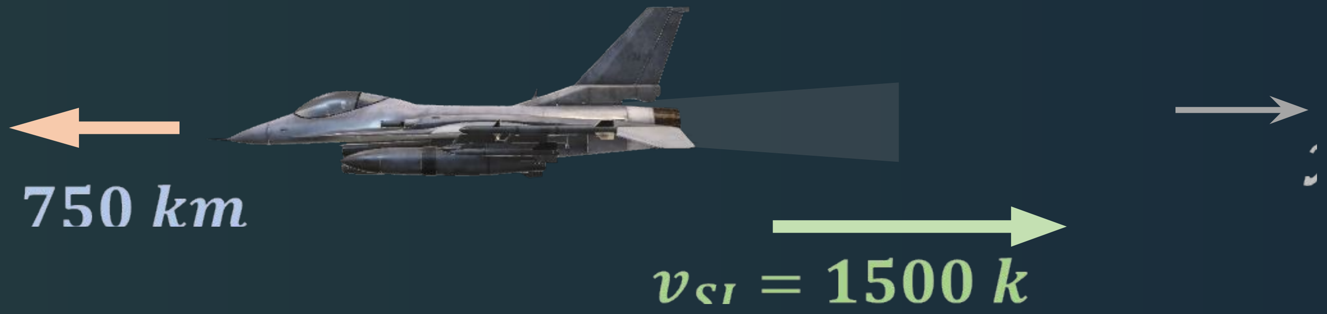
Example

Two ships $20\ km$ away start to move towards each other. Speeds of ship A and ship B are $50\ km/hr$ and $70\ km/hr$ respectively. After how much time will they cross each other?

- A — $10\ min$
- B — $15\ min$
- C — $30\ min$
- D — $20\ min$

Example

A jet airplane travelling with a speed of **750 km/h** ejects its smoke at a speed of **1500 km/h** relative to jet. What is the velocity of smoke w.r.t an observer on the ground?



- **A** $750\ km/h(\hat{\imath})$
- **B** $85\ km/h(\hat{\imath})$
- **C** $85km/h(\hat{\jmath})$
- **D** $750\ km/h(\hat{\jmath})$

Example

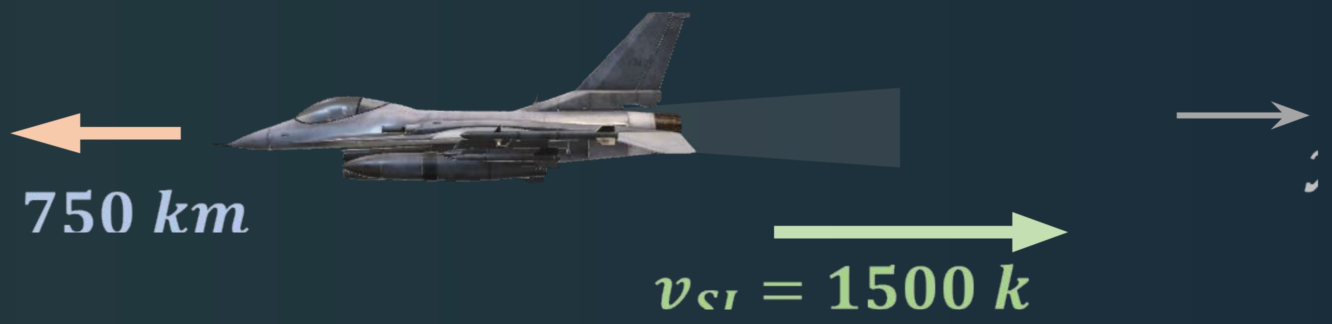
Given: $\vec{v}_J = -750\ km/h(\hat{\imath})$

$\vec{v}_{SJ} = 1500\ km/h(\hat{\imath})$

Relative Velocity: $\vec{v}_{SJ} = \vec{v}_S - \vec{v}_J$

$$\vec{v}_S = \vec{v}_{SJ} + \vec{v}_J$$

$$\vec{v}_S = 750\ km/h(\hat{\imath})$$



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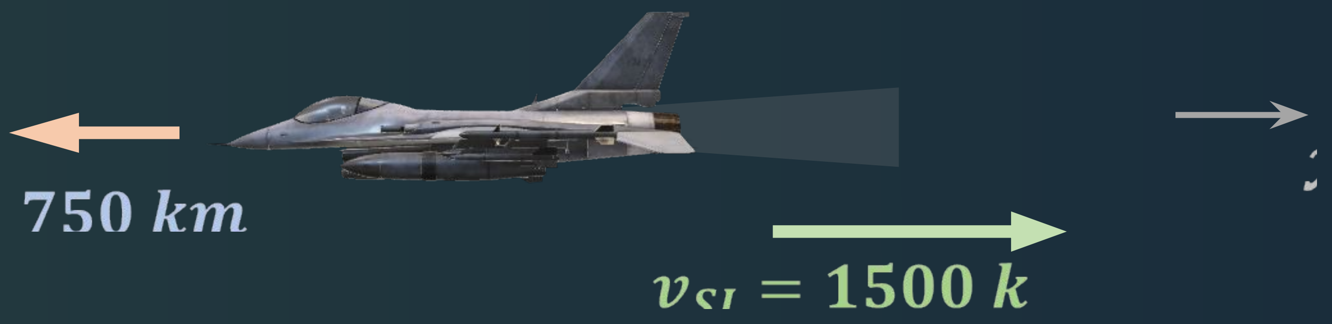
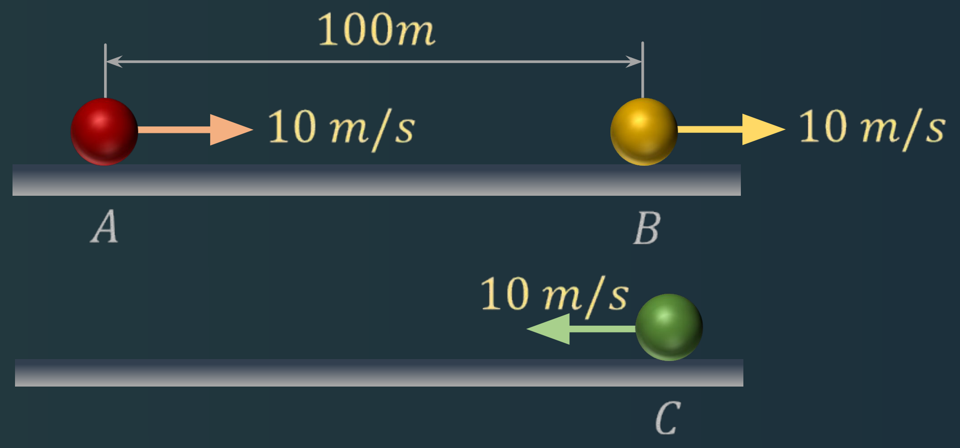


- A. $750\ km/h(\hat{\imath})$
- B. $85\ km/h(\hat{\imath})$
- C. $85 km/h(\hat{\jmath})$
- D. $750\ km/h(\hat{\jmath})$

Example

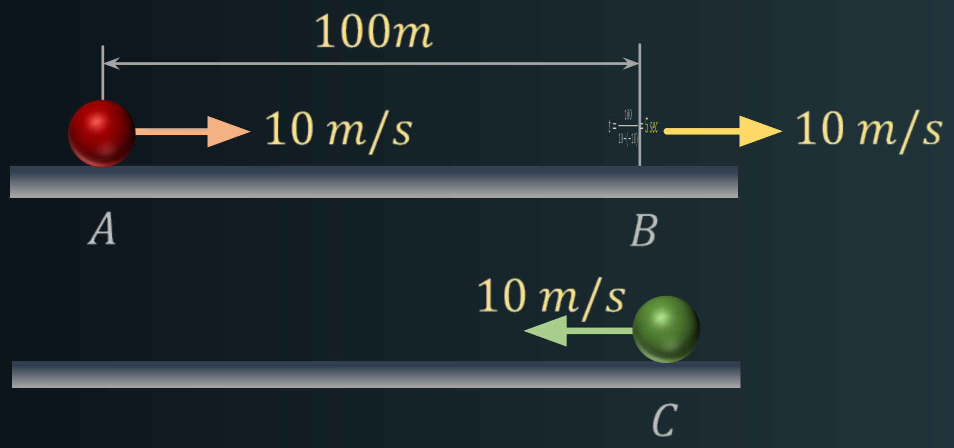
A particle A is moving with a speed $10\ m/s$ towards right while particle B is moving at a speed of $10\ m/s$ towards right and another particle C is moving at speed of $10\ m/s$ towards left. The separation between A and B is $100\ m$. The time interval between C meeting B and C meeting A is



- (A) $10\ s$
- (B) $5\ s$
- (C) $20\ s$
- (D) $12\ s$

Example

A particle A is moving with a speed $10\ m/s$ towards right while particle B is moving at a speed of $10\ m/s$ towards right and another particle C is moving at speed of $10\ m/s$ towards left. The separation between A and B is $100\ m$. The time interval between C meeting B and C meeting A is

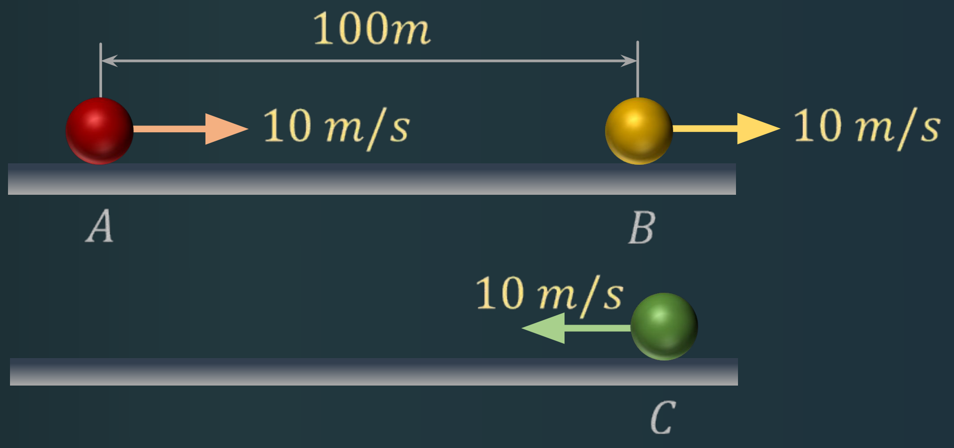


$$t = \frac{\text{Separation between } A \text{ and } B}{\text{Relative Velocity of } A \text{ w.r.t } C}$$

$$t = \frac{100}{10-(-10)} = 5\ sec$$

Example

A particle A is moving with a speed $10\ m/s$ towards right while particle B is moving at a speed of $10\ m/s$ towards right and another particle C is moving at speed of $10\ m/s$ towards left. The separation between A and B is $100\ m$. The time interval between C meeting B and C meeting A is



A. $10\ s$

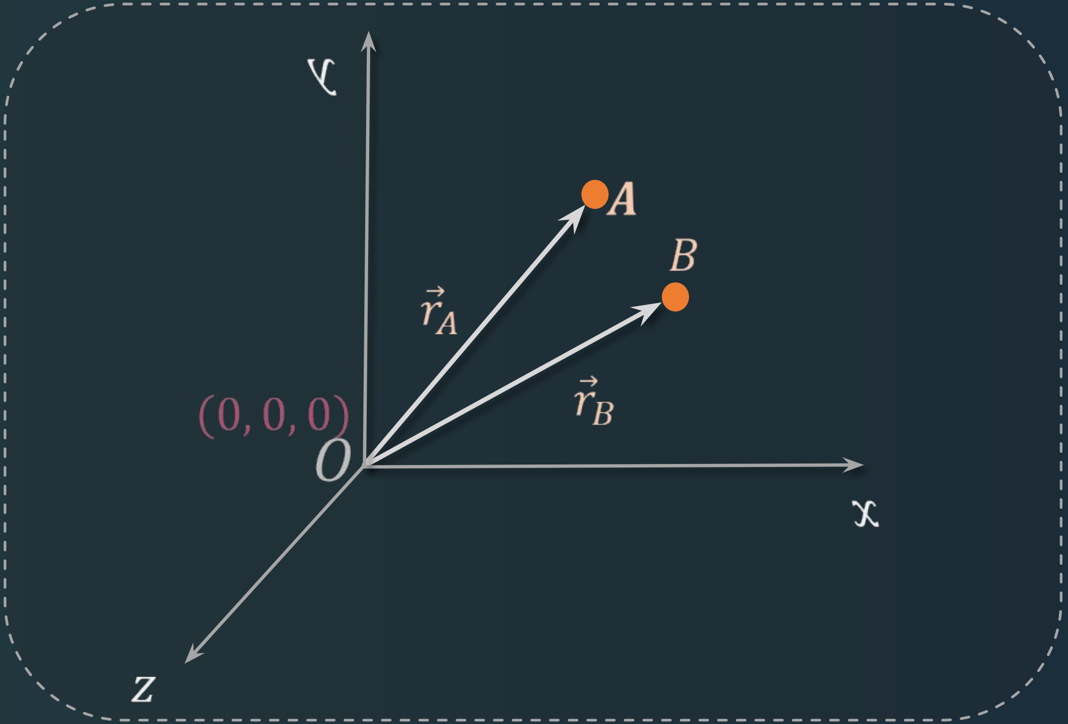
B. $5\ s$

C. $20\ s$

D. $12\ s$

Relative Motion in 2-D

Relative position: $\vec{r}_{AB} = \vec{r}_A - \vec{r}_B$



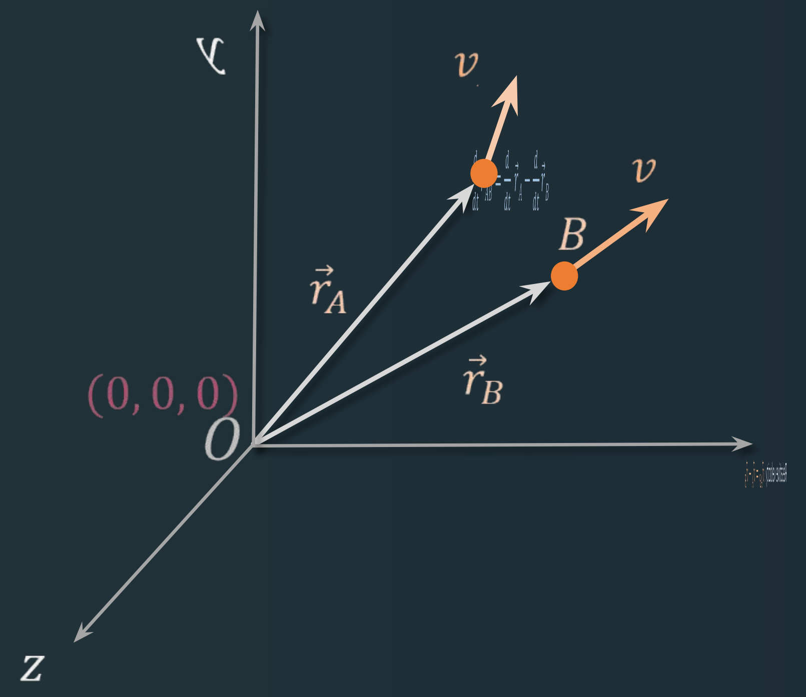
Relative Motion in 2-D

Relative position: $\vec{r}_{AB} = \vec{r}_A - \vec{r}_B$

Differentiating both sides, we get

$$\frac{d}{dt}\vec{r}_{AB} = \frac{d}{dt}\vec{r}_A - \frac{d}{dt}\vec{r}_B$$

Relative velocity: $\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$



Relative Motion in 2-D

Relative position: $\vec{r}_{AB} = \vec{r}_A - \vec{r}_B$

Differentiating both sides, we get

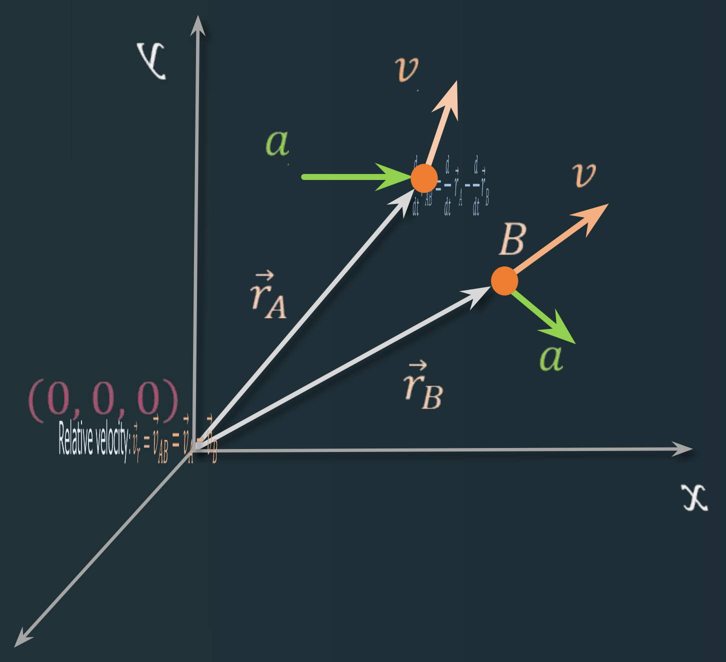
$$\frac{d}{dt}\vec{r}_{AB} = \frac{d}{dt}\vec{r}_A - \frac{d}{dt}\vec{r}_B$$

Relative velocity: $\vec{v}_r = \vec{v}_{AB} = \vec{v}_A - \vec{v}_B$

Differentiating again on both sides, we get

$$\frac{d}{dt}\vec{v}_{AB} = \frac{d}{dt}\vec{v}_A - \frac{d}{dt}\vec{v}_B$$

Relative acceleration: $\vec{a}_r = \vec{a}_{AB} = \vec{a}_A - \vec{a}_B$



Relative Motion in 2-D

$$v_r = u_r + a_r t$$

$$s_r = u_r + \frac{1}{2} a_r t^2$$

$$v_r^2 = u_r^2 + 2 a_r s_r$$

Example

On a two-lane road car A is travelling with the speed of $\mathbf{36\ km/h}$. Two cars B and C approach car A from opposite directions with speed of $\mathbf{54\ km/h}$ each. At an instant when AB and AC are both equal to $\mathbf{1\ km}$, B decides to overtake A before C does. What minimum acceleration of B is required to avoid an accident?

A. $2\ m/s^2$

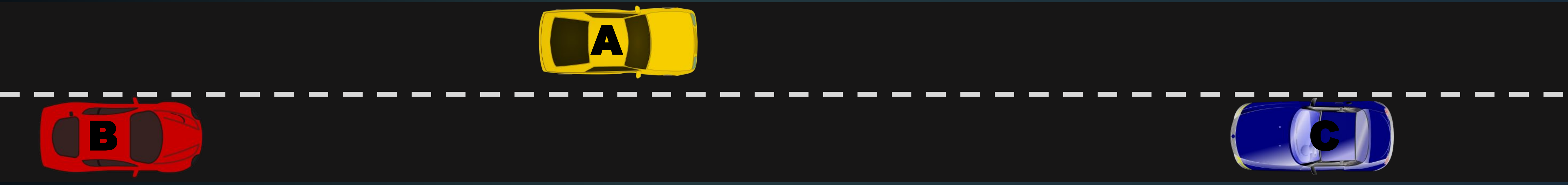
B. $4\ m/s^2$

C. $10\ m/s^2$

D. $1\ m/s^2$

Example

On a two-lane road car A is travelling with the speed of $36\ km/h$. Two cars B and C approach car A from opposite directions with speed of $54\ km/h$ each. At an instant when AB and AC are both equal to $1\ km$, B decides to overtake A before C does. What minimum acceleration of B is required to avoid an accident?



Example

Here, $v_{BA} = v_B - v_A = 18 km/hr$

$v_{CA} = v_C - v_A = -90\ km/hr$

$$S_{CA} = v_{CA}t + \frac{1}{2}a_{CA}t^2$$

Given: $S_{CA} = 1\ km, v_{cA} = 90\ km/h$

$$-1 = -90 \times t + 0$$

$$t = \frac{1}{90} hr$$

$$S_{BA} = v_{BA}t + \frac{1}{2}a_{BA}t^2$$

$$1 = 18 \times \frac{1}{90} + \frac{1}{2}a_{BA}\left(\frac{1}{90}\right)^2$$

Example

$$\frac{4}{5} = \frac{1}{2} a_{BA} \left(\frac{1}{90}\right)^2$$

$$a_{BA} = \frac{8}{5} \times 90^2 \ \frac{km}{hr^2}$$

$$a_{BA} = 1 m/s^2$$

$$a_{BA} = a_B - a_A$$

$$a_B = a_{BA} + a_A = 1\ m/s^2$$

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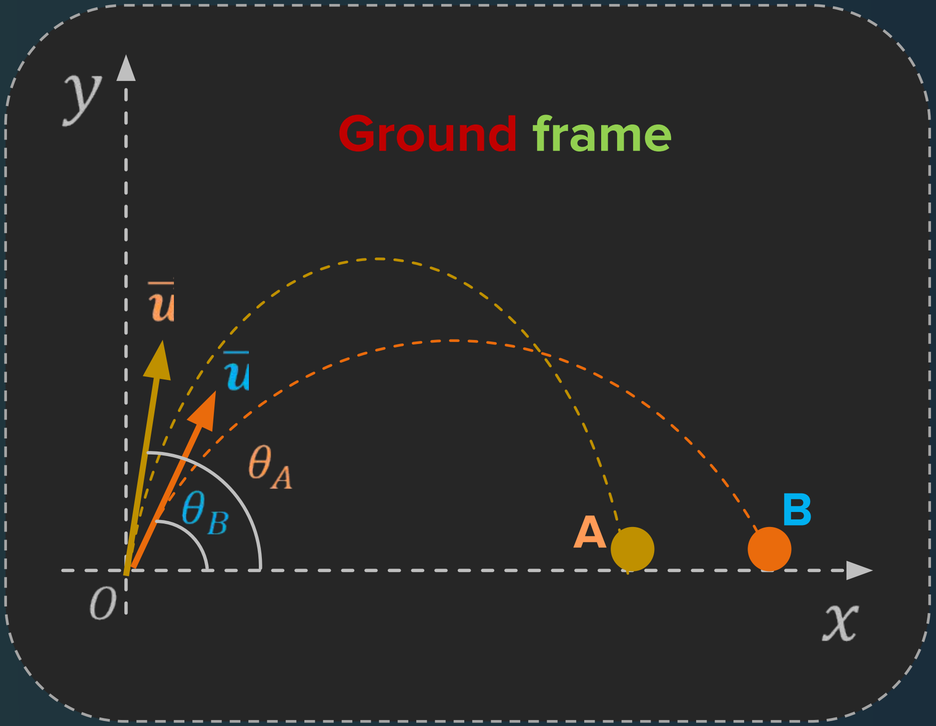
Relative motion of projectiles

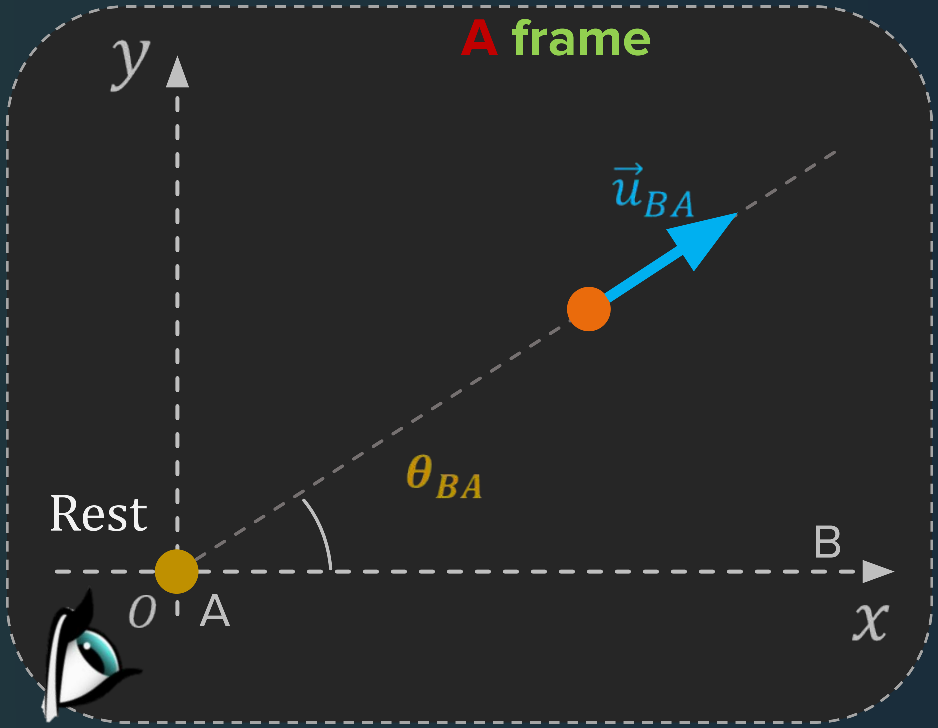
Let's consider two balls A & B projected with speeds u_A and u_B respectively.

Ground frame



Relative motion of projectiles

A frame



Example

A person sitting at the rear end of the compartment throws a ball towards the front end. The ball follows a parabolic path. The train is moving with uniform velocity of $20\ ms^{-1}$. A person standing outside on the ground also observes the ball. How will the maximum height (h_m) attained and the ranges (R) seen by thrower and the outside observer compare each other?

A. Same h_m and R

B. Same h_m different R

C. Different h_m and R

D. Different h_m same R

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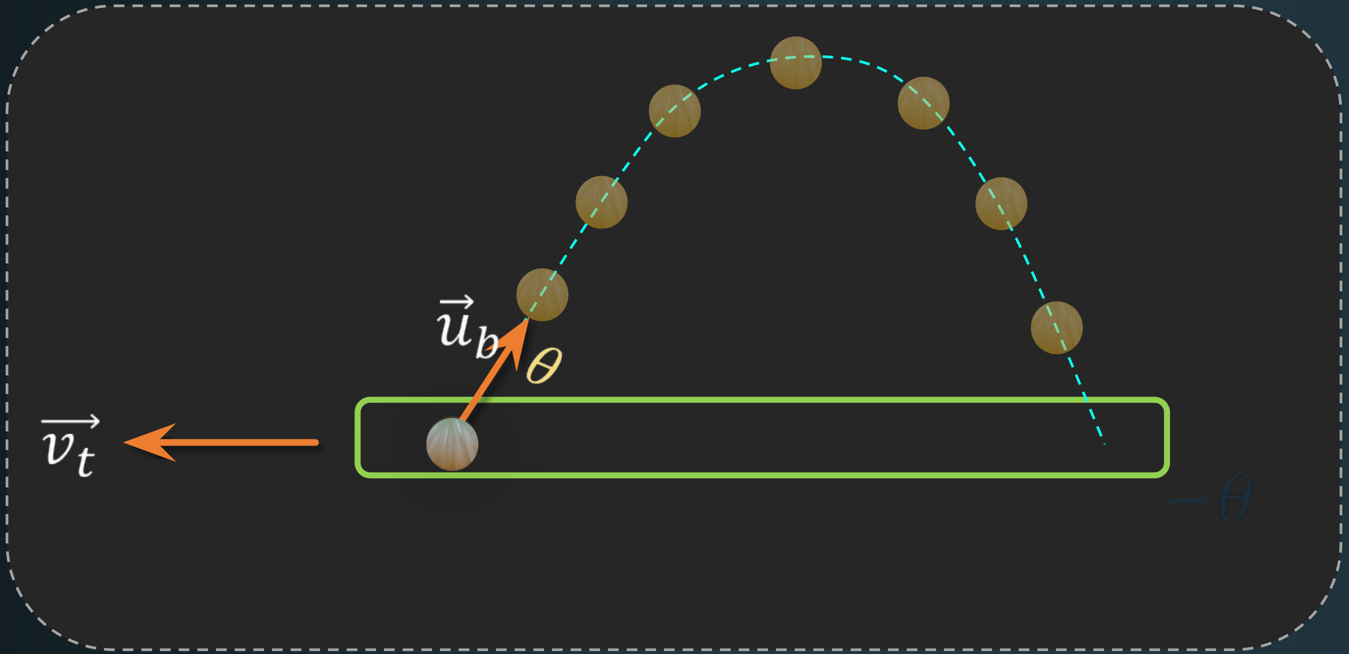

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The motion of the train will affect only the horizontal component of the velocity of the ball while the vertical component will remain same for the observer standing outside.

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A. Same h_m and R

B. Same h_m different R

C. Different h_m and R

D. Different h_m same R

12TH CLASS | TUESDAY, THURSDAY
11TH CLASS | MONDAY, WEDNESDAY, FRIDAY

3 PM | 4 PM | 5 PM | 6 PM

VIVEK SIR

CHEMISTRY | 3:00 PM

ANUSHRI MA'AM

PHYSICS | 4:00 PM

SACHIN SIR

ZOOLOGY | 5:00 PM

PANKHURI MA'AM

BOTANY | 5:00, 6:00 PM

PUSHPENDU SIR

ZOOLOGY | 6:00 PM

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