Chapter 2: Straight Line Kinematics. Motion in 1-Dimension.

Even if you never had a physics class before, you probably know an equation for speed.

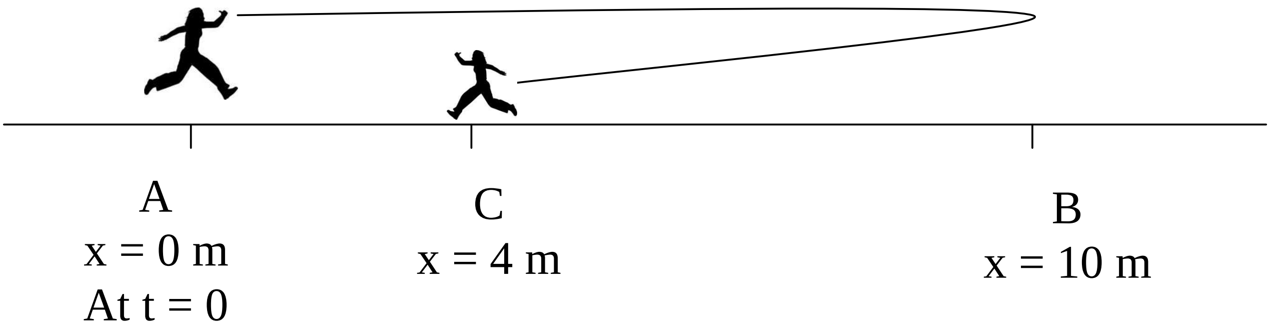
$$speed = \frac{\text{distance covered}}{\text{time}}$$

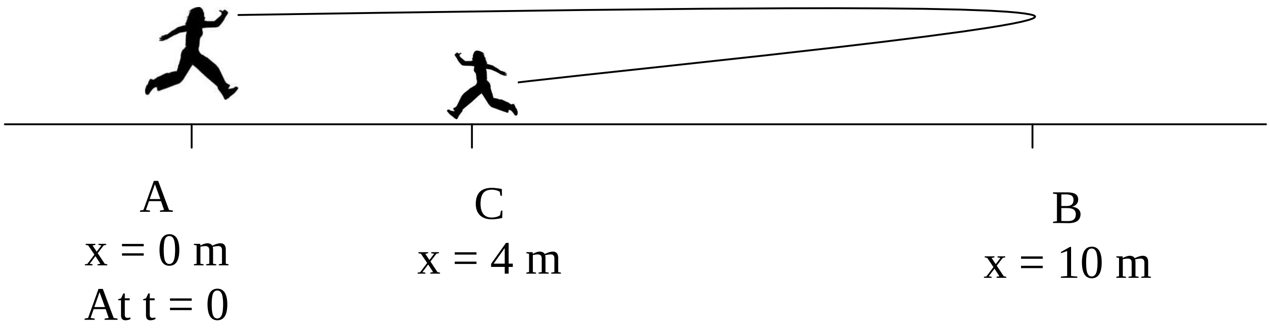
actually it's $$average\,speed = \frac{\text{distance covered}}{\text{time}}$$

$$\bar{s} = \frac{\text{distance covered}}{\text{time}}$$

You walk from A to B to C in 10 seconds.

We let x describe your position on the road.



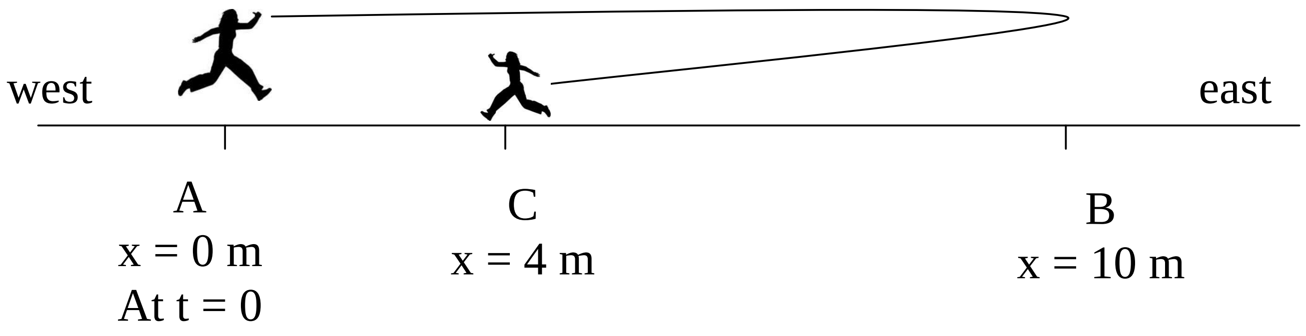


For the 10-second trip A -> B -> C:

What is the total distance, d? d = ________

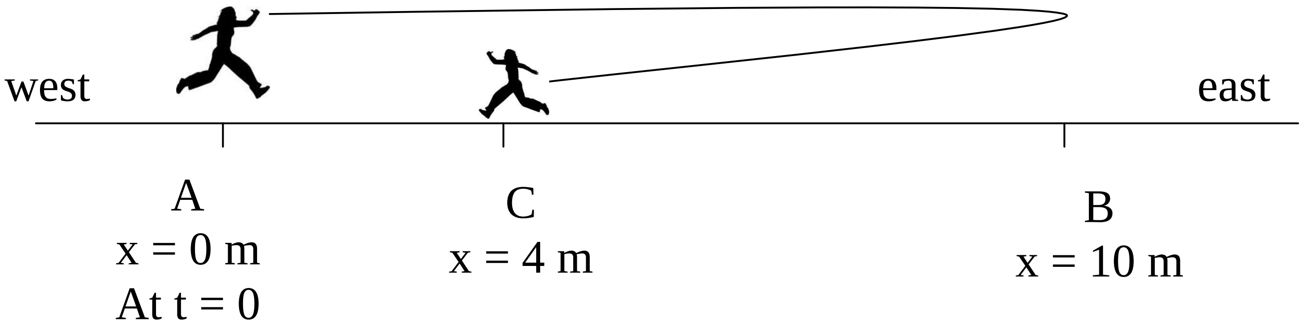
What is the average speed $\overline{S}$?

$$\bar{s} = \frac{\text{distance covered}}{\text{time}} = \frac{\text{d}}{\text{t}} = \frac{16m}{10s} = 1.6\,\frac{m}{s} \approx 3.5\frac{miles}{hour}$$



Distance *d* and speed *s* are SCALAR quantities.

A scalar is a quantity that has only magnitude (size). It does not have a direction.
Ex: time, mass, $$



We define your displacement, Δx , as your 'change in position'.

$\Delta x = x_{final} - x_{initial}$

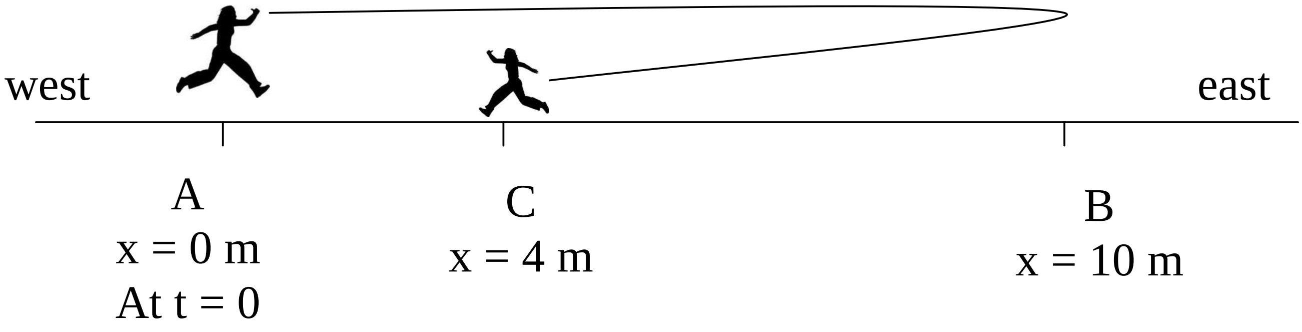
For ABC:

$\Delta x = 4m - 0m = 4m.$

The '+' sign tells us that the displacement is to the right (east).

Displacement is a VECTOR quantity.

A vector is a quantity that has both magnitude and direction.



Displacement, $\Delta x = 4$ m

Or $\Delta x = 4$ m $\Delta x = 4m \angle east$

magnitude direction

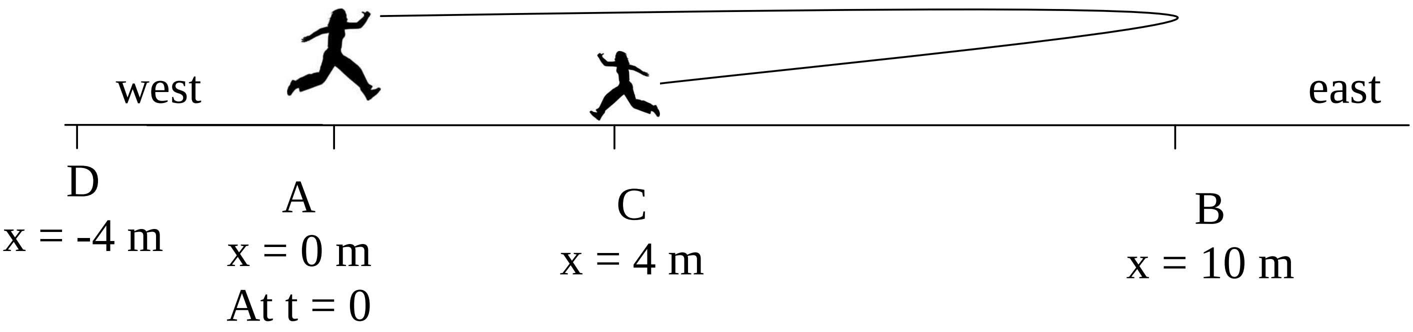
Your average velocity $\bar{v}$ is your 'rate of change of position':

$$\bar{v} = \frac{\text{change in position}}{\text{time}} = \frac{\Delta x}{t} = \frac{4m}{10s} = 0.4\frac{m}{s} \approx 0.9\frac{miles}{hour}$$

$$\bar{v} = 0.4\frac{m}{s} \quad or \quad \bar{v} = 0.4\frac{m}{s}\angle east$$

velocity is a vector

You keep walking for 5 more seconds to point D.



For the entire trip ABCD:

distance d = ___________

Displacement $\Delta x = x_f - x_o$ = -4m - 0m = -4m

average speed is $\bar{s} = \frac{d}{t} = \frac{24\text{m}}{15\text{s}} = 1.6\,\frac{m}{s} \approx 3.5\frac{miles}{hour}$

average velocity

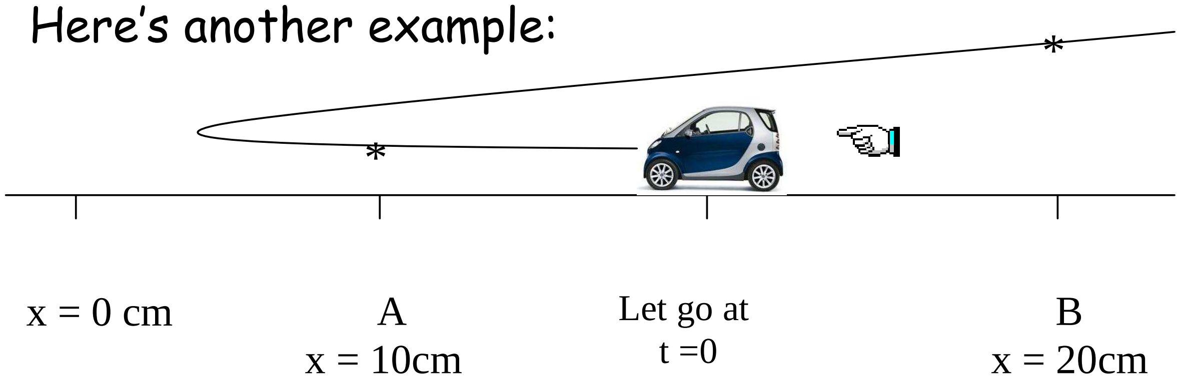
$$\bar{v} = \frac{\Delta x}{t} = \frac{-4m}{15s} = -0.27\,\frac{m}{s} \approx -0.6\frac{miles}{hour}$$

or

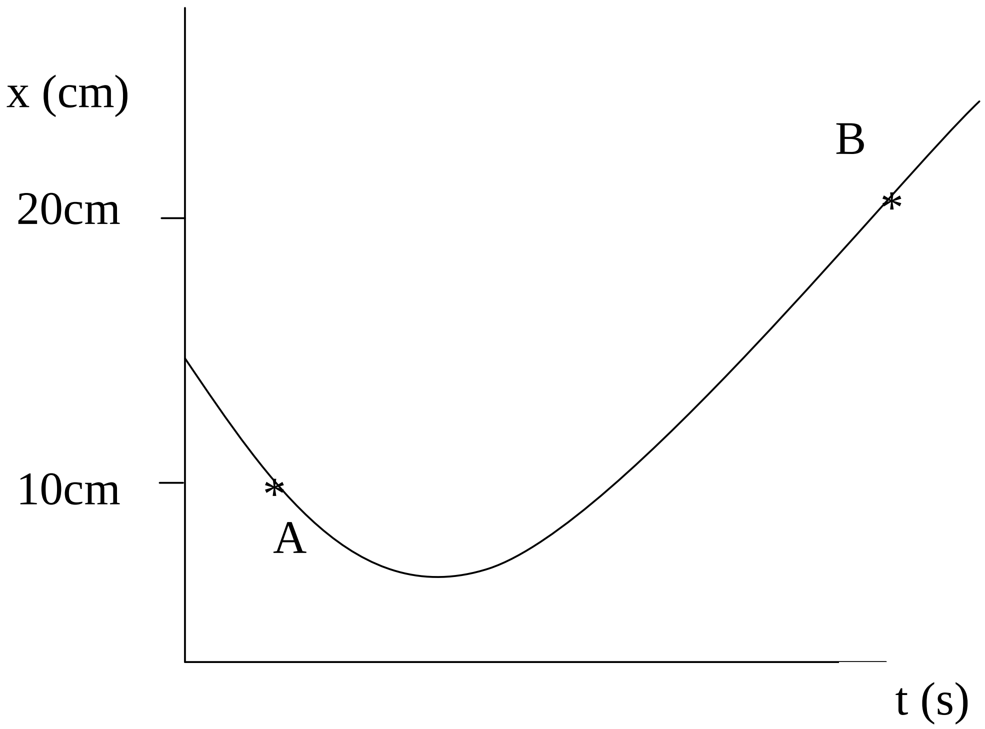
$$\bar{v} = 0.27\frac{m}{s}\angle west$$

Again, distance 'd' and displacement 'Δx' are two different concepts.

Here's another example:

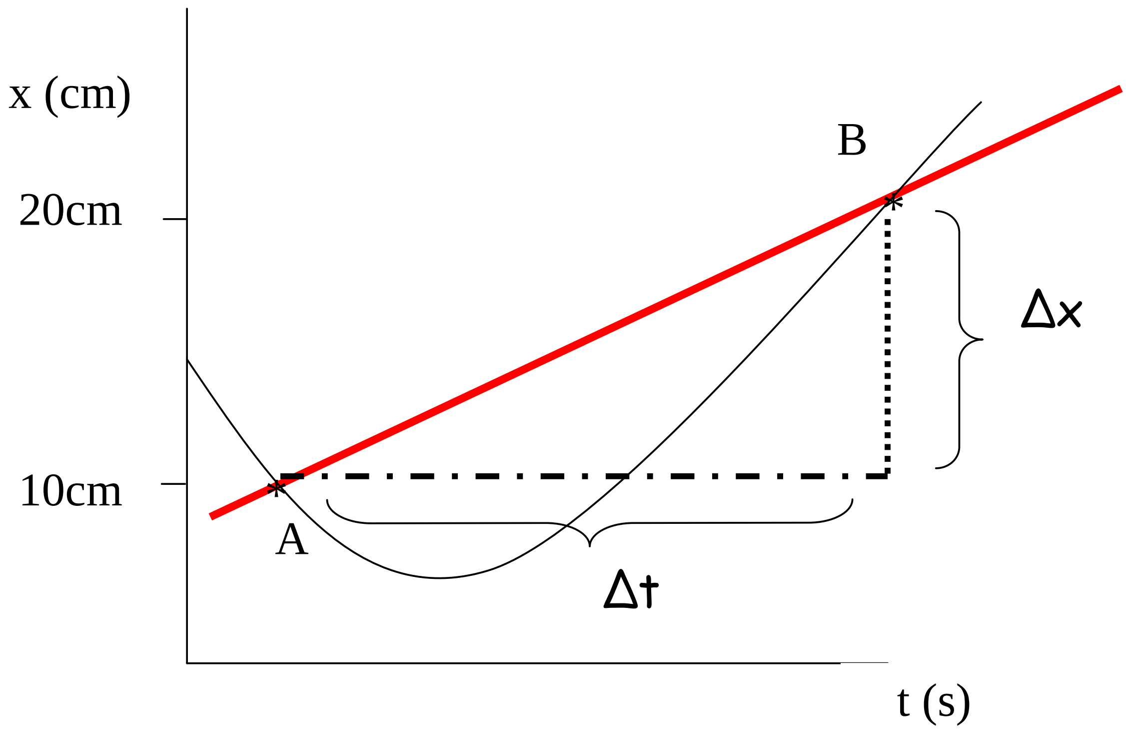


After the car is let go at t = 0, it moves from point A to B in 2 seconds.
Make a graph of position vs. time for the car for $t \geq 0$.



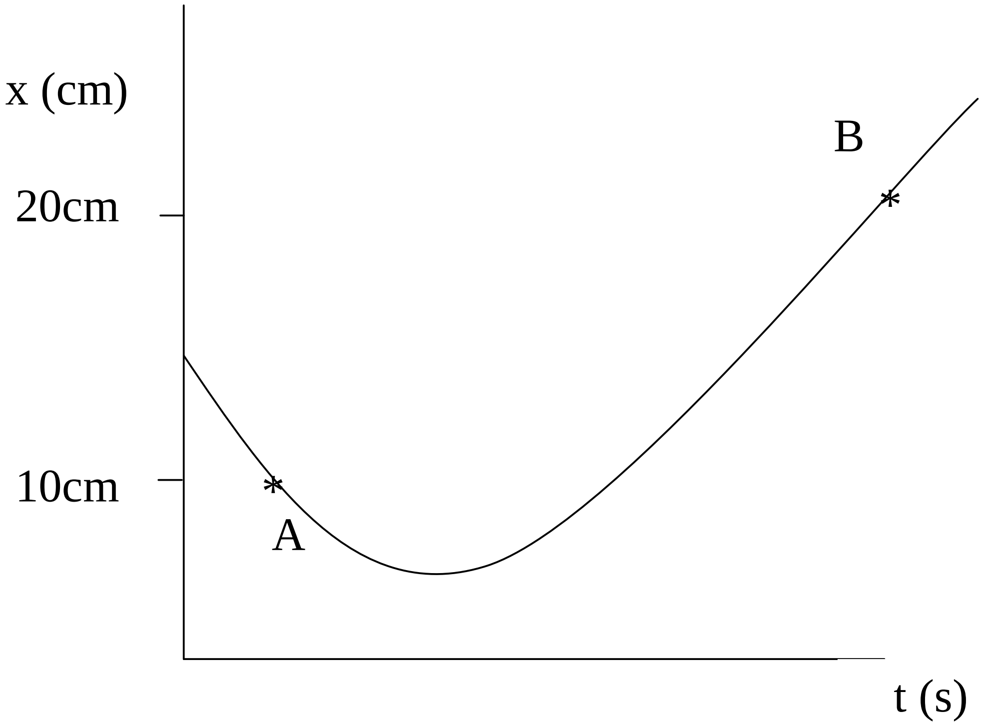
Now find the average velocity from A to B.

$$\bar{v} = \frac{\Delta x}{t} = \frac{rise}{run} = \text{ the slope of the \_\_\_\_\_\_\_\_\_\_ line.}$$



$$\bar{v} = \frac{\Delta x}{t} = \frac{rise}{run} = \frac{10cm}{2s} = 5\,\frac{\text{cm}}{s}$$

What is the velocity at point A?? v_A = ??



To find the v_A , we must shrink the time interval AB to zero.

As t → zero, the slope of the secant line AB

approaches the slope of the _____________ line

at point A.

The slope of this line at A gives us the instantaneous velocity v.

What quantity does your car's speedometer measure?

You will need to understand the difference between velocity and speed.

When a car 'speeds up' or 'slows down' we say it accelerates.

Acceleration = the rate of change of velocity.

average acceleration is :

$$\bar{a} = \frac{\Delta v}{\Delta t} \quad \text{which we will write as} \quad \bar{a} = \frac{\Delta v}{t}$$

A | B
t = 0 | t = 10s
$v_o = 0$ | $v_f = 30$ m/s

For $\overline{AB}$, the average acceleration $\bar{a}$ is:

$$\bar{a} = \frac{\Delta v}{\Delta t} \; or \; \frac{\Delta v}{t} = \frac{v_f - v_o}{t} = \frac{30\,m/s - 0\,m/s}{10s} = 3\,\frac{\frac{m}{s}}{s} = 3\frac{m}{s^2}$$

The car's velocity changed (increased) by 3 m/*s each second.*

Now slam on the brakes and stop in 6 seconds:

B

C

Car moving
At 30 m/s
Now applies
the brakes.

v_f = 0 m/s

For $\overline{BC}$, the average acceleration $\bar{a}$ is:

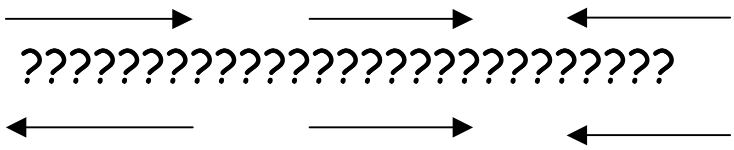
$$\bar{a} = \frac{\Delta \mathrm{v}}{\Delta \mathrm{t}} \; or \; \frac{\Delta \mathrm{v}}{\mathrm{t}} = \frac{v_f - v_o}{t} = \frac{0\,m/s - 30\,m/s}{6s} = -5\,\frac{\frac{\mathrm{m}}{s}}{s} = -5\frac{m}{s^2}$$

It's negative.

The car's velocity changed (decreased) by 5 m/*s each second.*

Negative and positive velocities, and negative and positive accelerations do NOT tell you what the car is doing.

However, the signs of both *v* and *a* together do tell you information about the motion.



If you want to find the acceleration of the car at some instant, you use the same process that was used earlier to find the instantaneous velocity v.

Namely, just find the average acceleration over an infinitesimally small time interval around the particular time of interest.

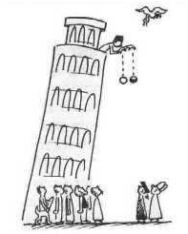
We’ll usually study motion with constant acceleration (cars, objects moving under the influence of gravity, …).

In these cases, if a = constant, then it doesn’t change.
It stays the same.

Thus the average acceleration is the same as the instantaneous acceleration.

$$\overline{a} = a$$

We can use this idea to find the velocity of the car at some arbitrary time, say, t = 4.3 seconds.



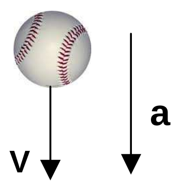
Bodies in Freefall

Freefall - only under the influence of gravity.

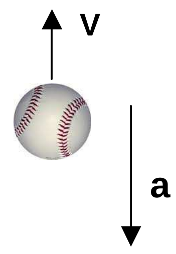
Neglecting air resistance, all bodies in freefall experience the same constant* downward acceleration due to gravity of 9.81 $\frac{m/s}{s}$, or 9.81 $\frac{m}{s^2}$.

(* for our purposes, near the Earth's surface, this is ~ constant.)

Falling:



Gravity acts to *add* 9.81 m/s of vertical speed each second.



Rising:

Gravity acts to *take away* 9.81 m/s of vertical speed each second.

The magnitude (size, #, absolute value, amount…) of the acceleration due to gravity is called '*g*', where *g* is the number 9.81 m/s^2.

Note: *g* is the numeric value 9.81 m/s^2,

it is NEVER negative.

Thus $g = 9.81\ m/s^2$ always! $g \neq -9.81\frac{m}{s^2}$

recall, $\overrightarrow{\text{a vector}}$ = magnitude / direction

$\overrightarrow{\text{acceleration due to gravity}}$ = 9.81 m/s^2 / downward

or = *g* / downward