Concepts of Motion

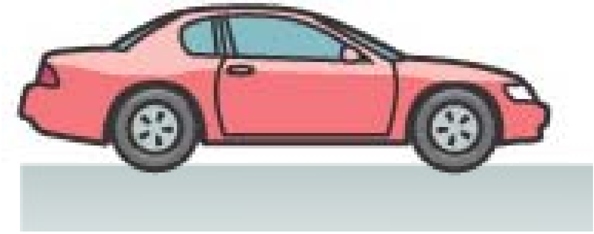
Readings: Chapter 1

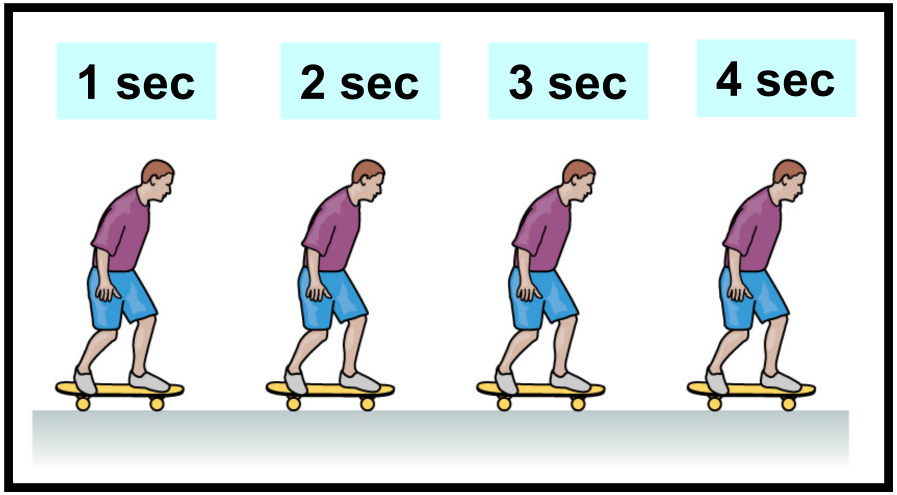
Displacement - vector

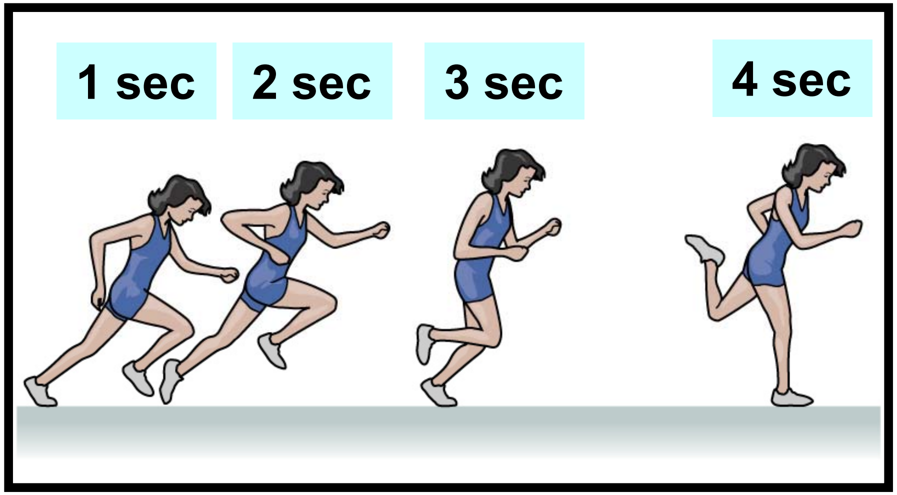
Velocity - vector

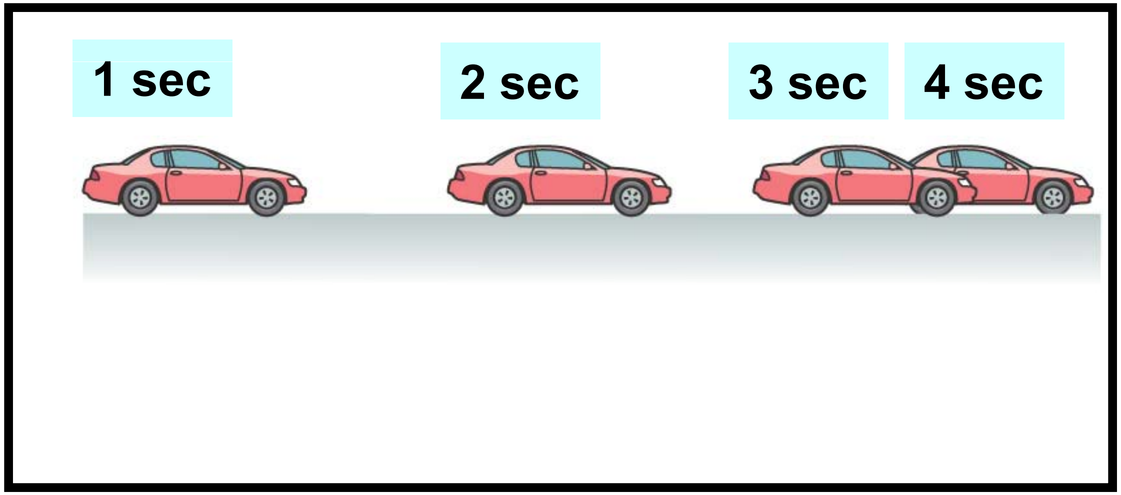
Acceleration – vector

Different types of motion





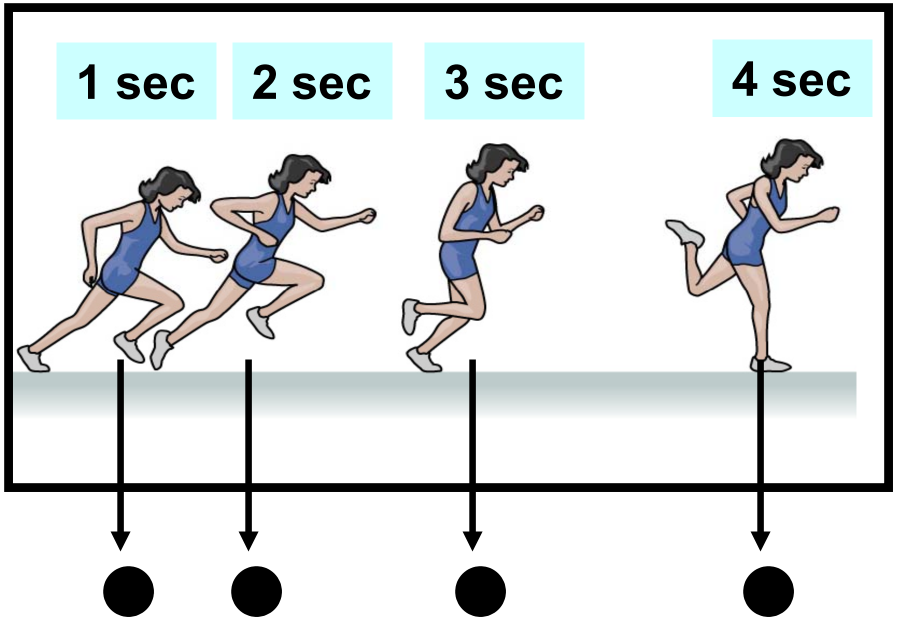




What is the difference between these motions?

How can we characterize these motions?

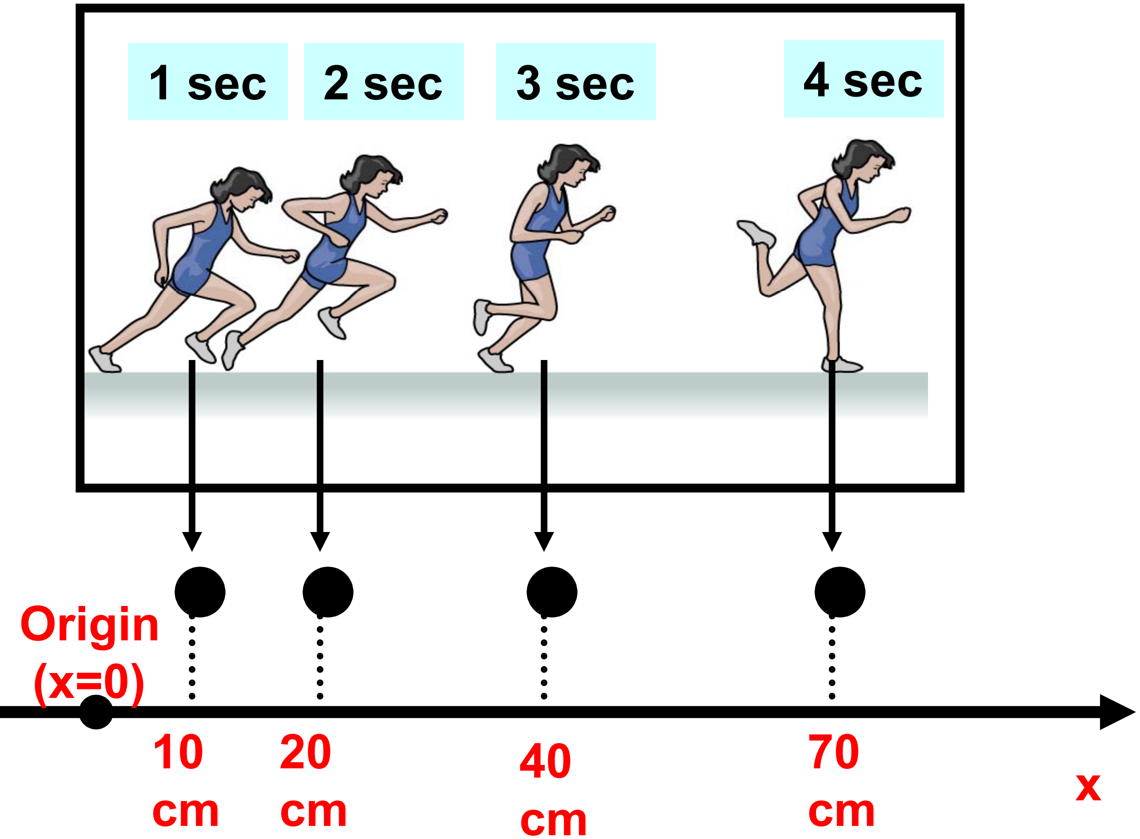
How can we characterize the motion?



The first step: PARTICLE MODEL – MOTION DIAGRAM

We consider object as a single point without size or shape, disregard internal motion of the object.

How can we characterize the motion?



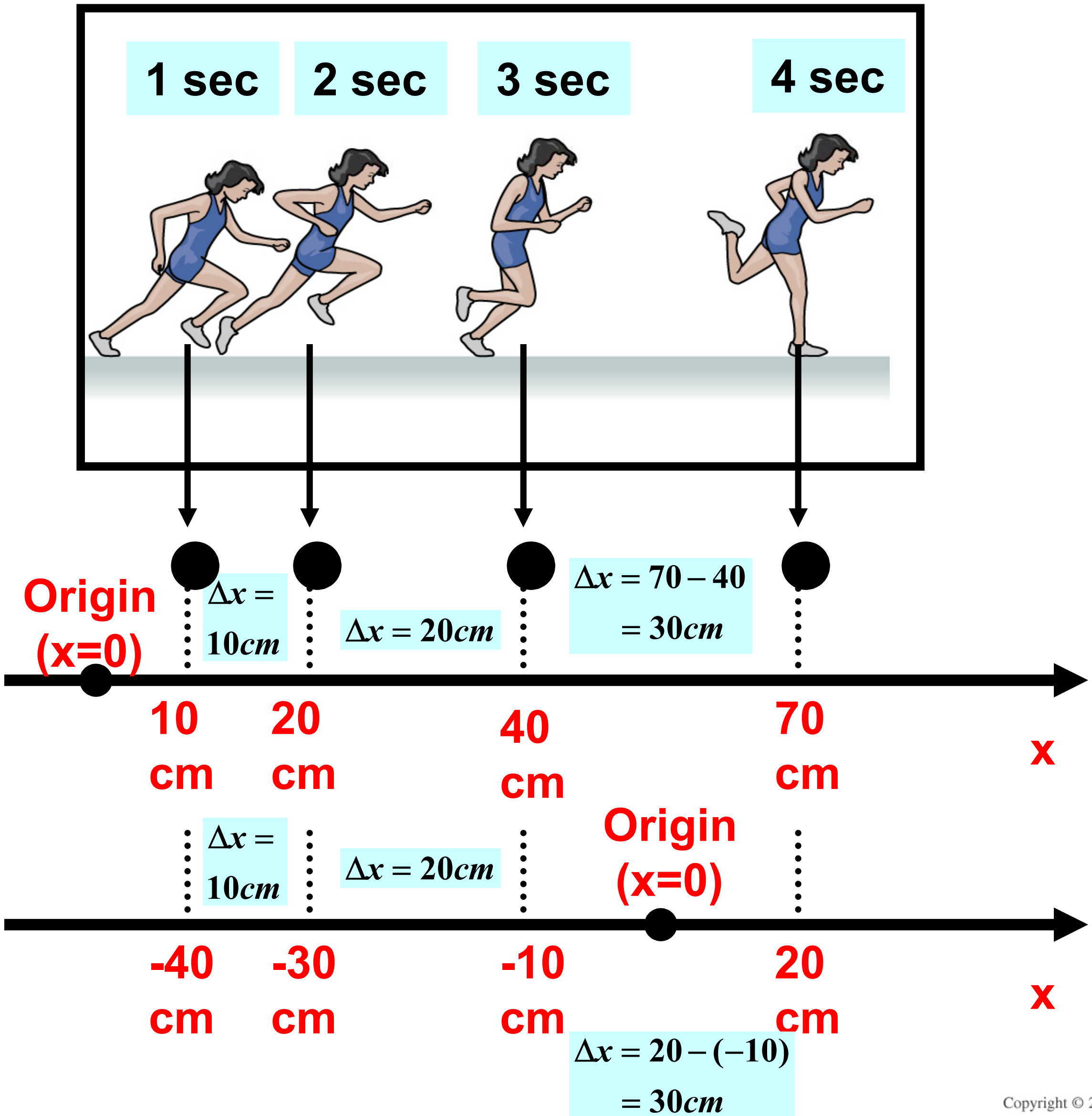
The second step: POSITION OF THE OBJECT (POINT) – COORDIANTE SYSTEM - DISPLACEMENT

We introduce coordinate system: for motion along a line - only *x* (which means that y=0);

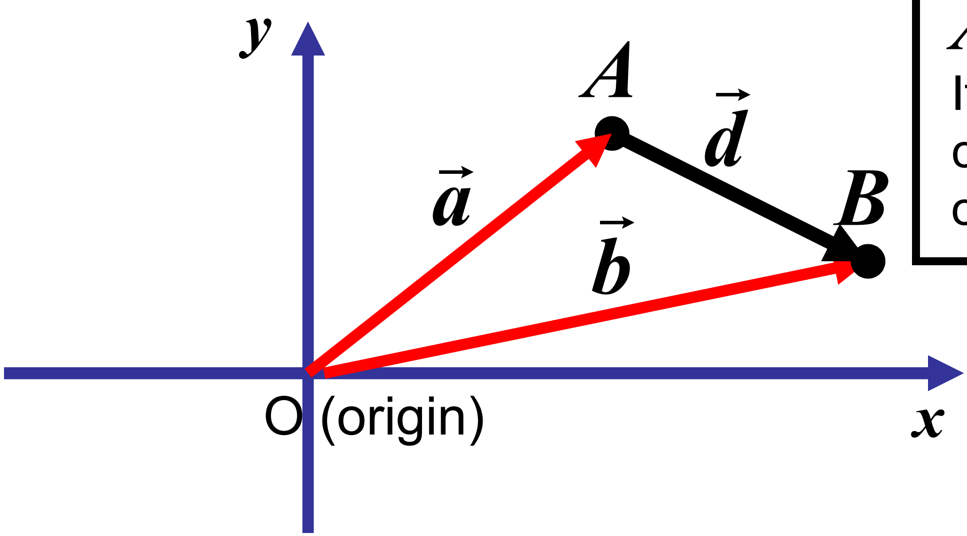
for a motion in a plane – x and y.

Different origins – different coordinates

Physical meaning – displacement - $\Delta x = x_2 - x_1$



Displacement



A - initial position of the object
If O is an origin then vector $\vec{a}$ characterizes initial position of the object

B - final position of the object
Vector $\vec{b}$ characterizes the final position of the object

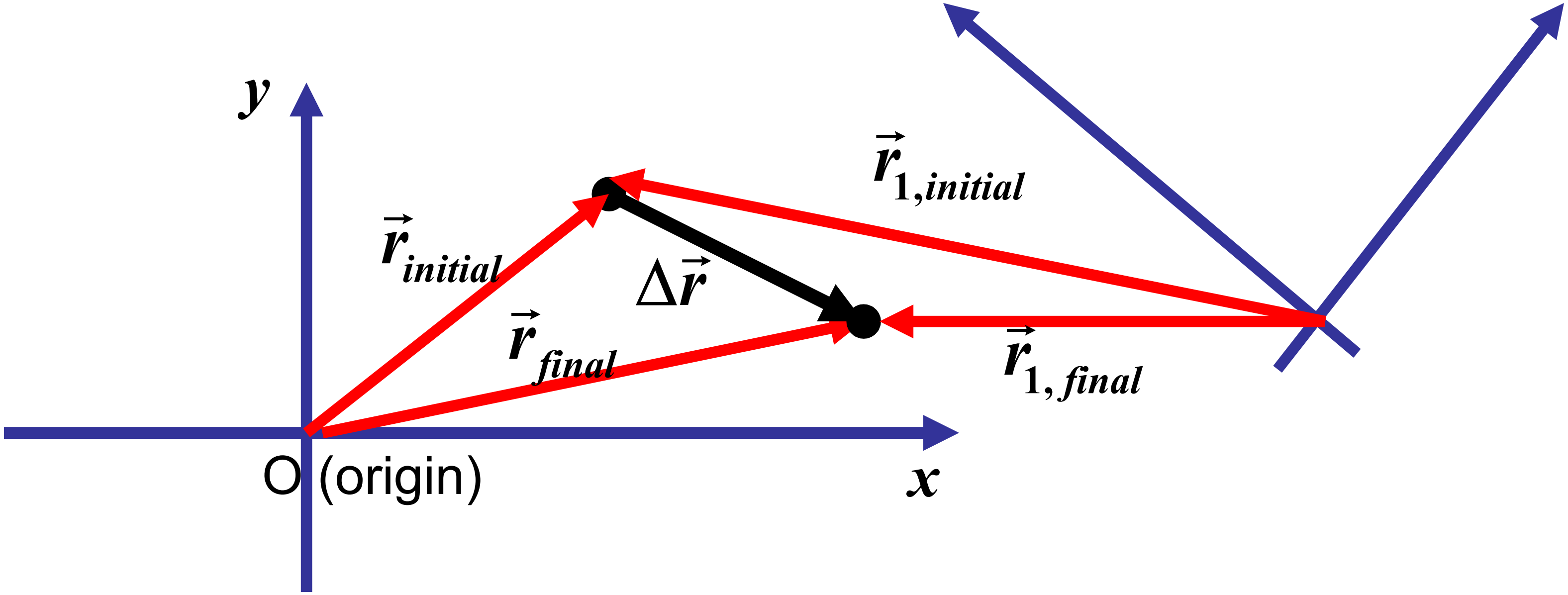
Vector $\vec{d}$ is a displacement (final position minus initial position – does not depend on coordinate system)

$$\vec{d} = \vec{b} - \vec{a}$$

Standard notation for displacement is $\Delta\vec{r}$

$$\Delta\vec{r} = \vec{r}_{final} - \vec{r}_{initial}$$

Displacement

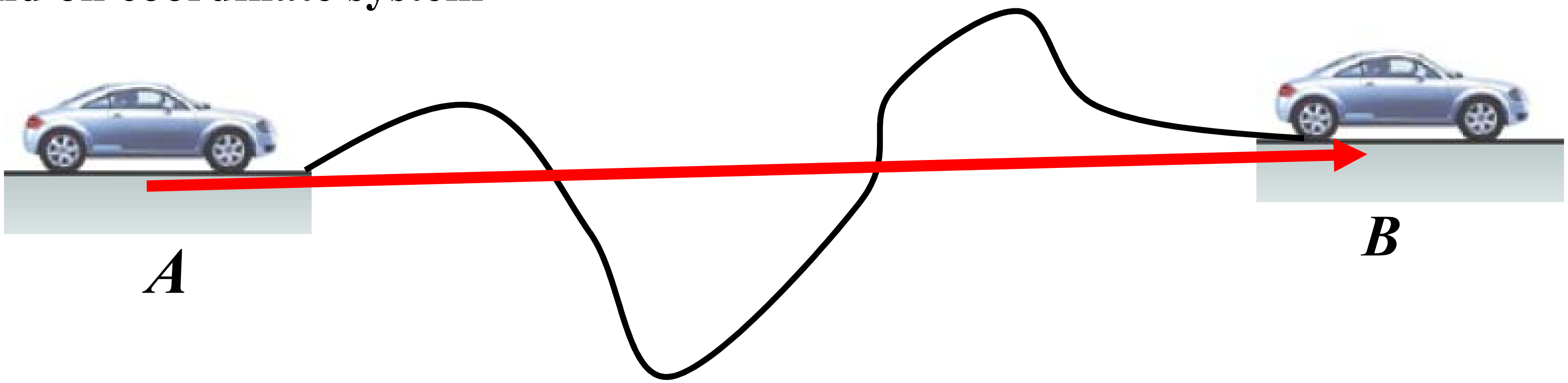


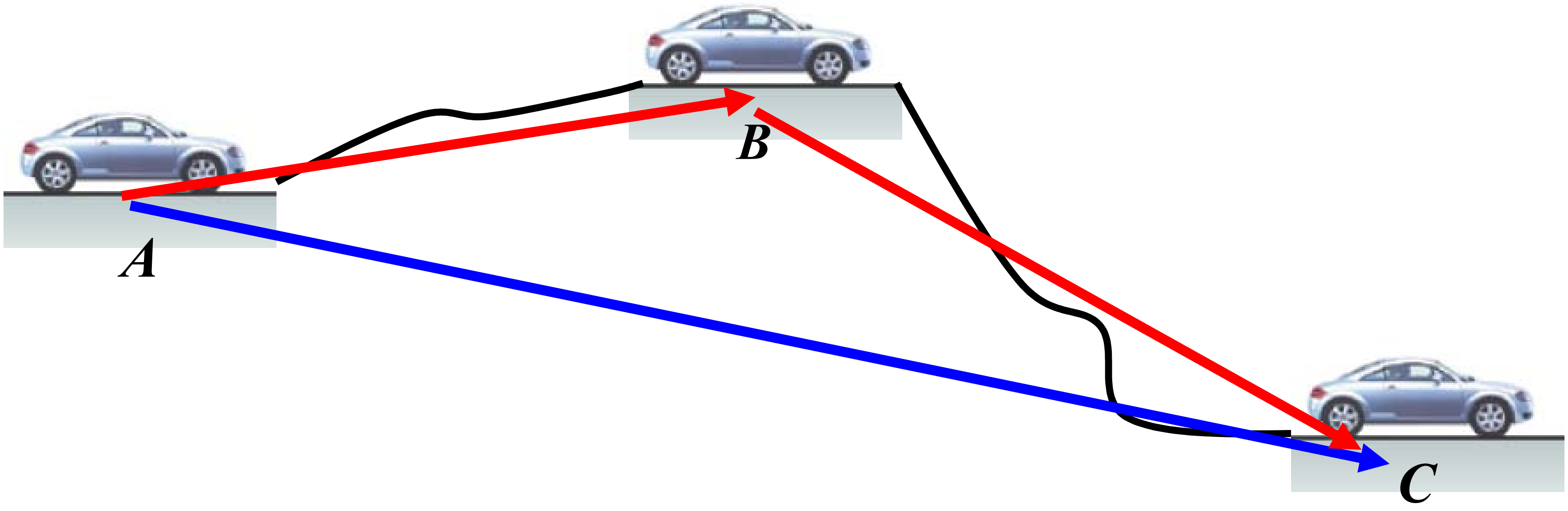
Displacement $\Delta\vec{r}$ **does not depend on coordinate system**

$$\Delta\vec{r} = \vec{r}_{final} - \vec{r}_{initial} = \vec{r}_{1,final} - \vec{r}_{1,initial}$$

Displacement

Displacement is a vector, it does not depend on coordinate system



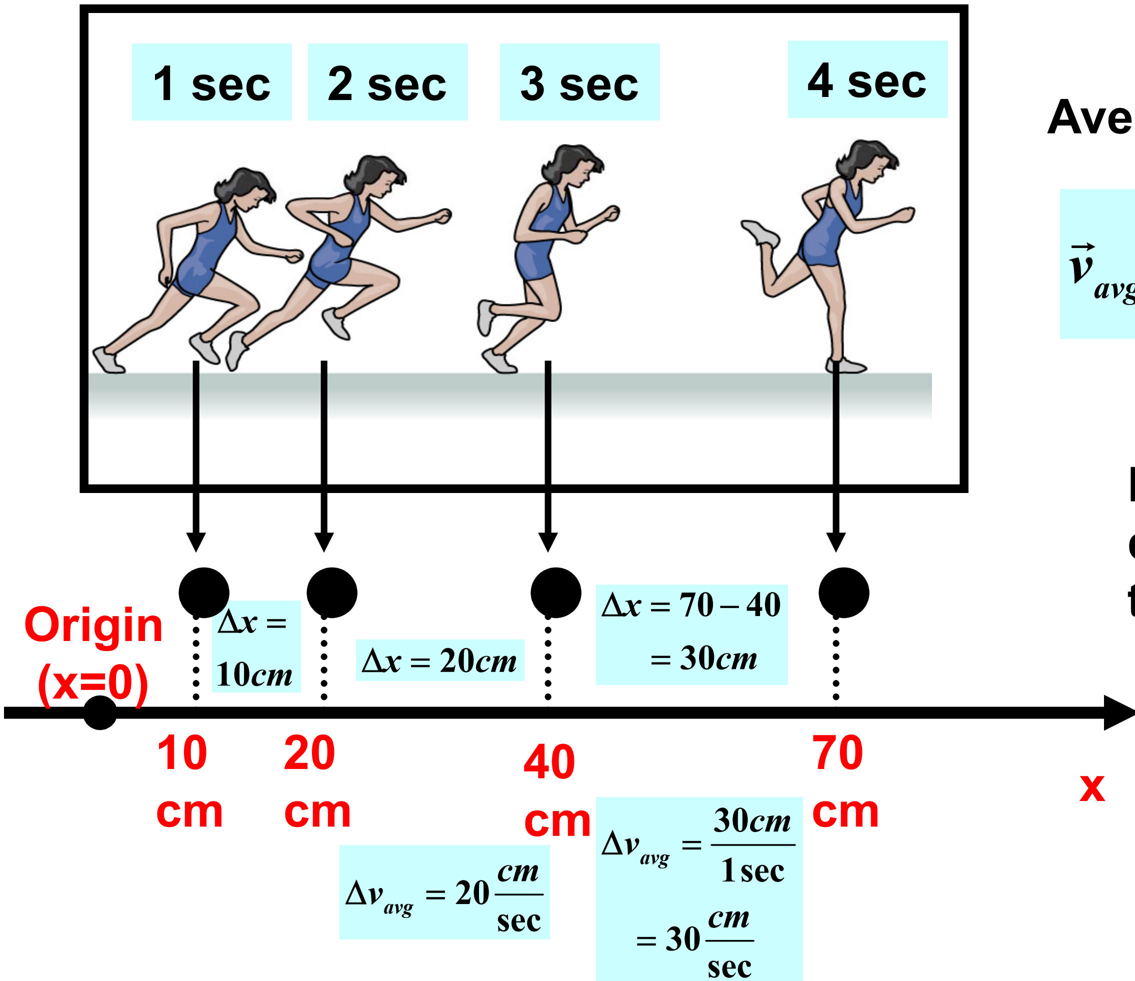


How can we characterize the motion?

The first step: PARTICLE MODEL – MOTION DIAGRAM

The second step: POSITION OF THE OBJECT (POINT) – DISPLACEMENT

The third step: (AVERAGE) VELOCITY



Average velocity is a vector:

$$\vec{v}_{avg} = \frac{displacement}{time} = \frac{\Delta\vec{r}}{\Delta t}$$

For a motion along the line – direction of velocity is along the line and the magnitude

$$v_{avg} = \frac{\Delta x}{\Delta t}$$

AVERAGE VELOCITY

$$\vec{v}_{avg} = \frac{displacement}{time} = \frac{\Delta\vec{r}}{\Delta t}$$

$$\vec{v}_{avg} \quad \frac{\Delta\vec{r}}{\Delta t}$$

The magnitude of velocity (vector) is called speed

Example:

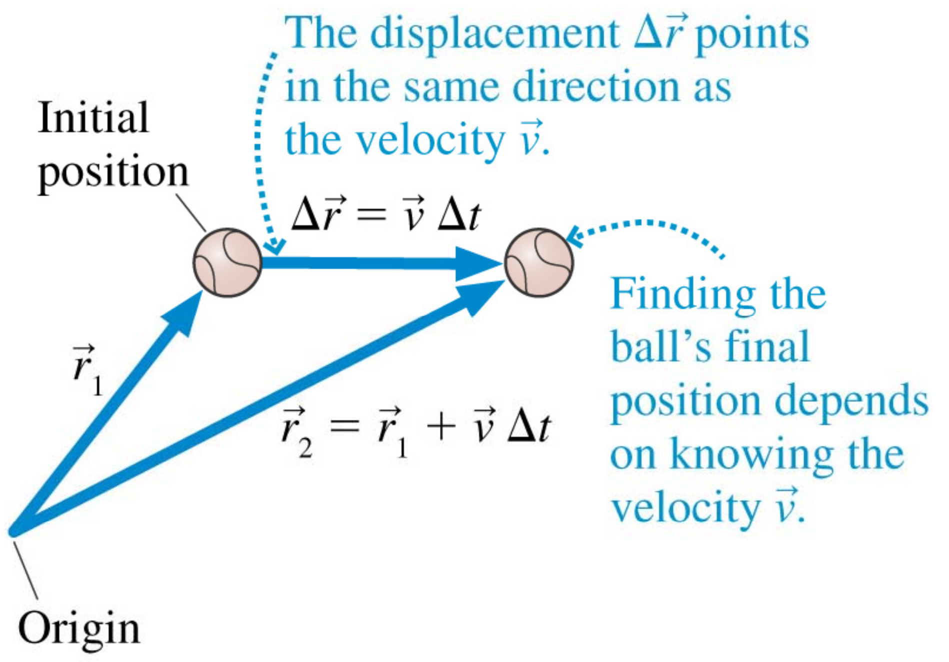
We know initial position of the object (in some coordinate system) - $\vec{r}_1$

We know the average velocity $\vec{v}$ **of the object during time** Δt

Then: What is the final position $\vec{r}_2$ **of the object?**

$$\vec{v} = \frac{displacement}{time} = \frac{\Delta\vec{r}}{\Delta t} = \frac{\vec{r}_2 - \vec{r}_1}{\Delta t}$$

$$\vec{r}_2 = \vec{r}_1 + \vec{v}\Delta t$$



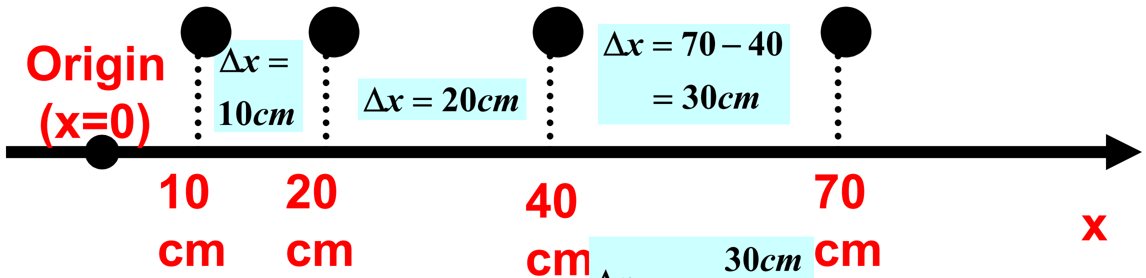
How can we characterize the motion?

The first step: PARTICLE MODEL – MOTION DIAGRAM

The second step: POSITION OF THE OBJECT (POINT) – DISPLACEMENT

The third step: (AVERAGE) VELOCITY

The forth step: (AVERAGE) ACCELERATION



$$\Delta v_{1,avg} = 20\frac{cm}{\sec}$$

$$\Delta v_{2,avg} = \frac{30cm}{1\sec} = 30\frac{cm}{\sec}$$

$$a_{avg} = \frac{v_{2,avg} - v_{1,avg}}{\Delta t} = \frac{(30-20)\frac{cm}{\sec}}{1\sec} = 10\frac{cm}{\sec^2}$$

The change in position is characterized by average velocity,

The change in velocity is characterized by average acceleration

$$\vec{a}_{avg} = \frac{\Delta\vec{v}}{\Delta t}$$

How can we characterize the motion?

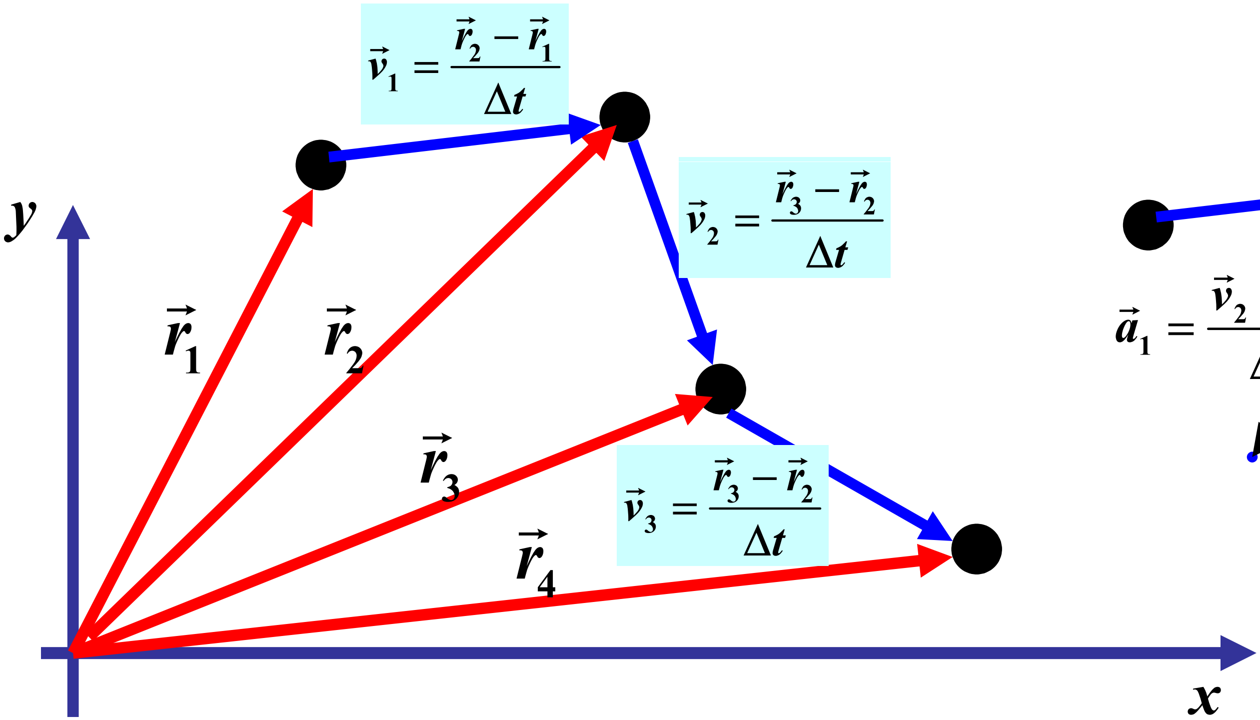
The first step: PARTICLE MODEL – MOTION DIAGRAM

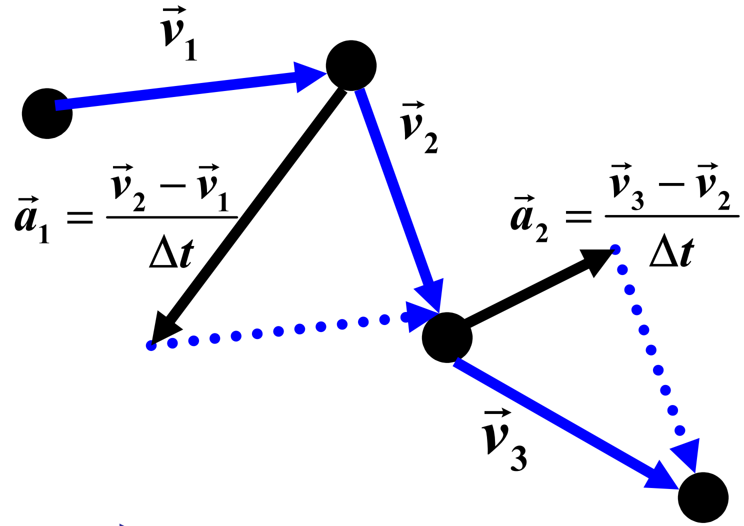
The second step: POSITION OF THE OBJECT (POINT) – DISPLACEMENT

The third step: (AVERAGE) VELOCITY

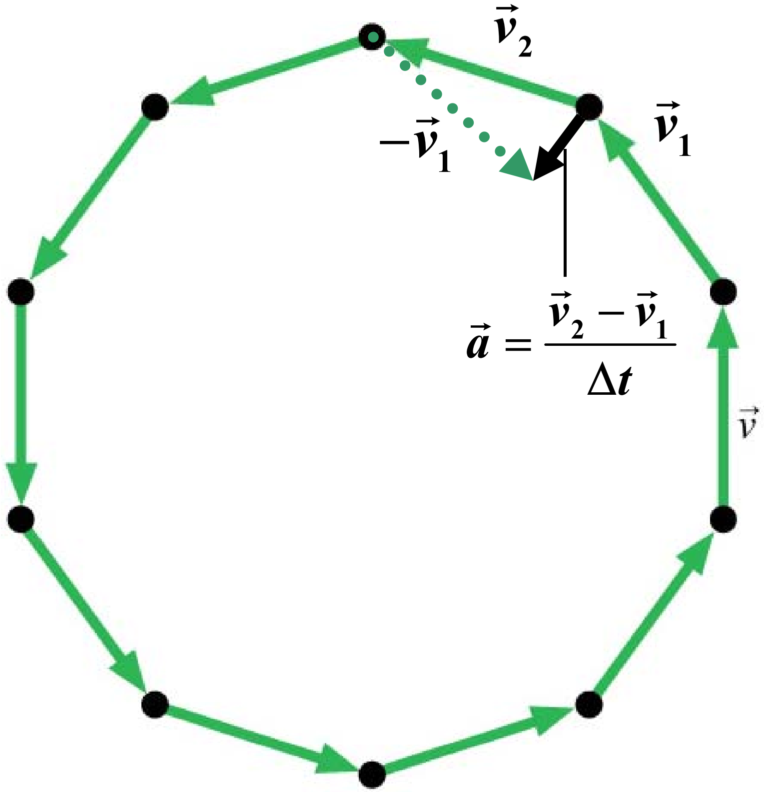
The forth step: (AVERAGE) ACCELERATION

$$\vec{v}_{avg} = \frac{\Delta \vec{r}}{\Delta t} \qquad \vec{a}_{avg} = \frac{\Delta \vec{v}}{\Delta t}$$

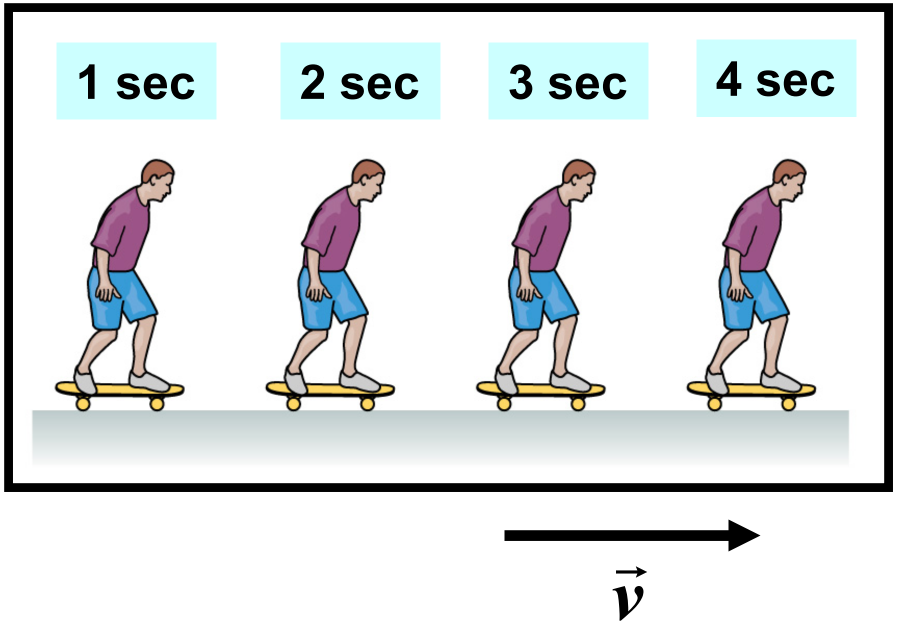




Acceleration is the change of velocity (speed can be the same)

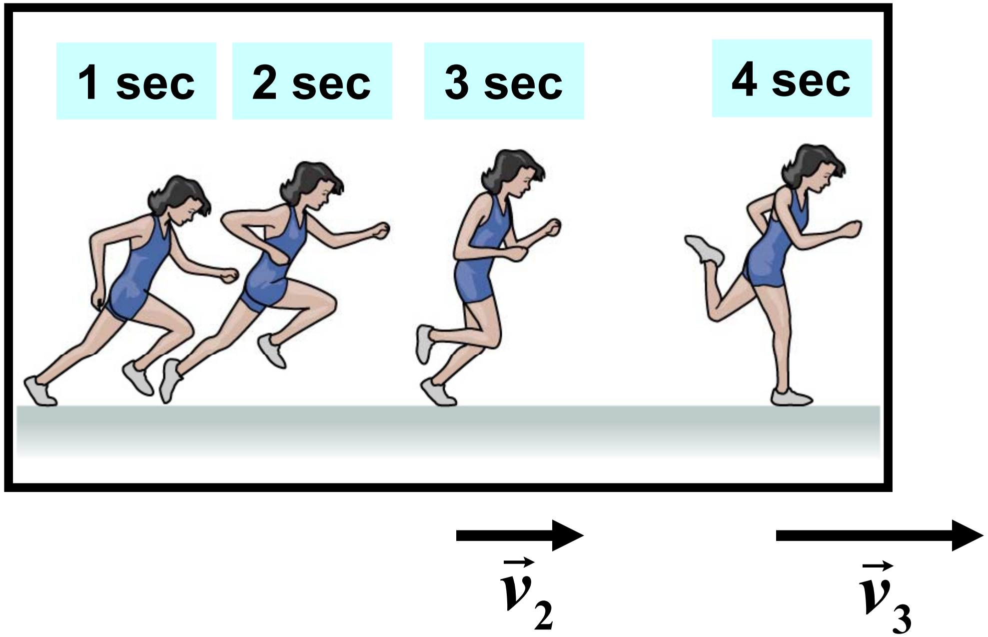


The lengths of the velocity vectors are the same, indicating constant speed, but the direction of each vector is different. This is a changing velocity.



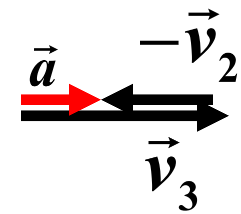
Velocity is the same – zero acceleration

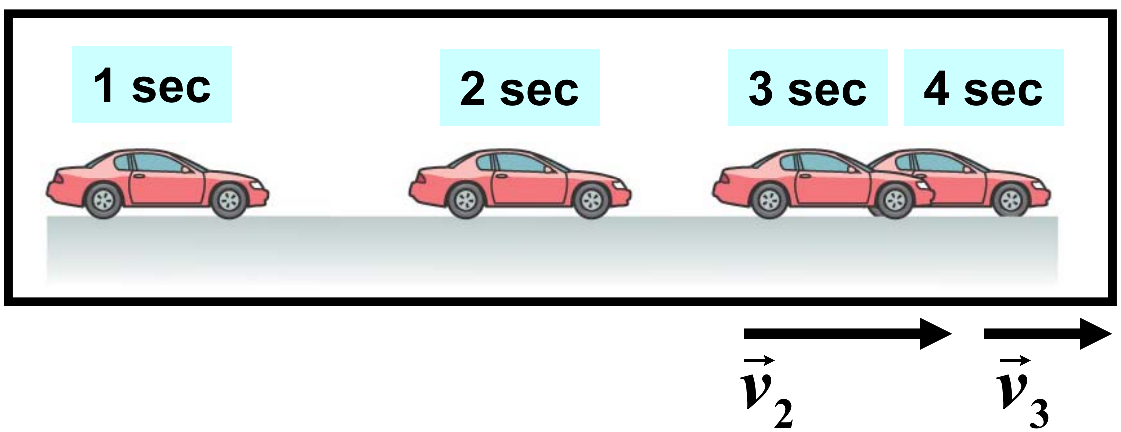
$$\vec{a}_{avg} = \frac{\Delta\vec{v}}{\Delta t} = 0$$



Velocity is increasing – acceleration has the same direction as velocity

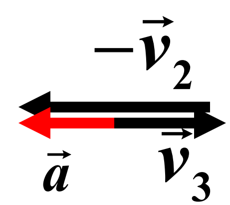
$$\vec{a} = \frac{\vec{v}_3 - \vec{v}_2}{\Delta t}$$



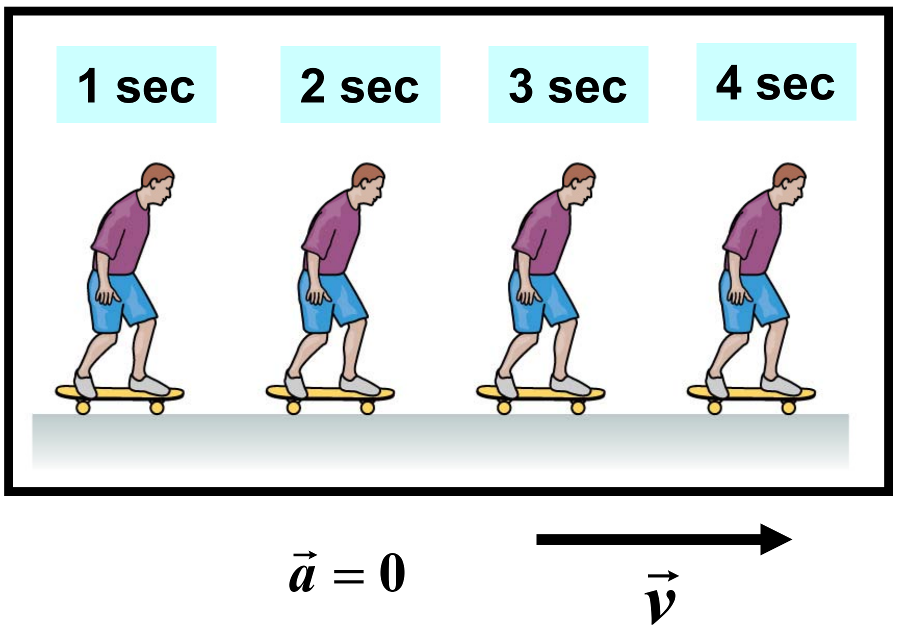


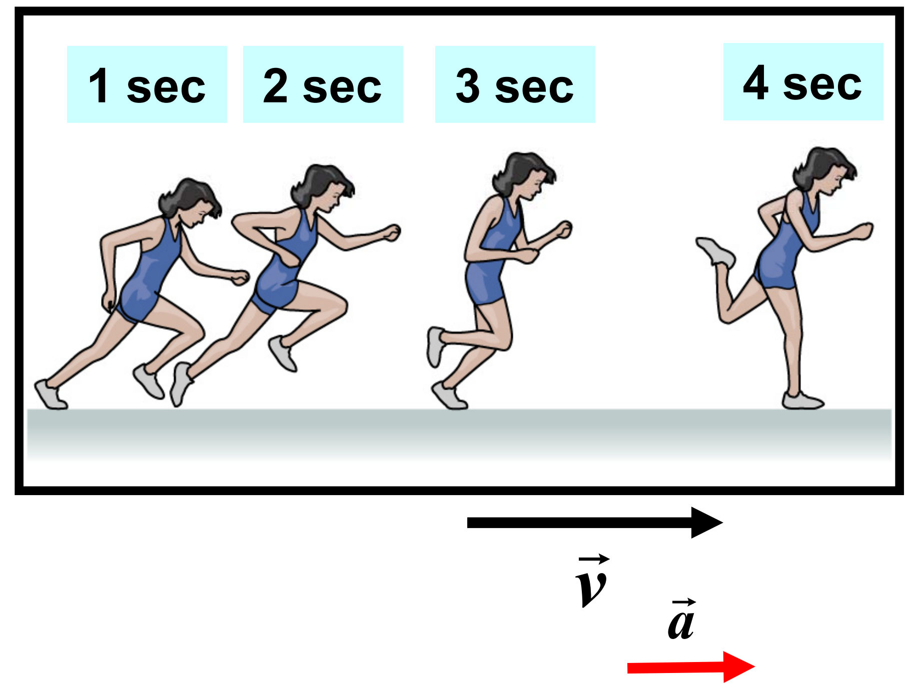
Velocity is decreasing – acceleration has the opposite direction

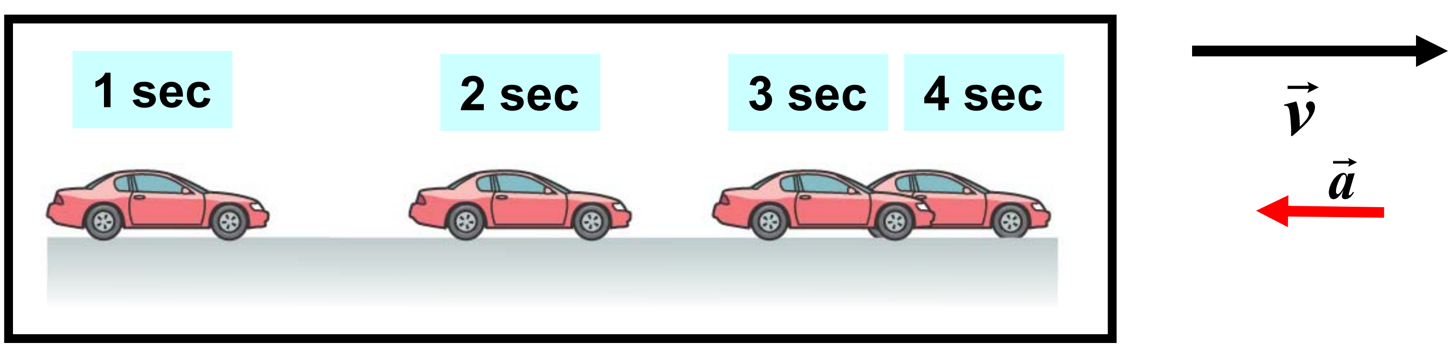
$$\vec{a} = \frac{\vec{v}_3 - \vec{v}_2}{\Delta t}$$



What is the difference between these motions?







SI units

Basic Units:

Time – seconds (s)

Length – meters (m)

Mass – kilogram (kg)

Units of velocity:

$$\vec{v}_{avg} = \frac{\Delta\vec{r}}{\Delta t} \rightarrow \frac{m}{s}$$

Units of acceleration:

$$\vec{a}_{avg} = \frac{\Delta\vec{v}}{\Delta t} \rightarrow \frac{m/s}{s} = \frac{m}{s^2}$$

TABLE 1.3 Useful unit conversions

1 in = 2.54 cm
1 mi = 1.609 km
1 mph = 0.447 m/s
1 m = 39.37 in
1 km = 0.621 mi
1 m/s = 2.24 mph