Chapter 2. Motion in 1-dimension

Why do we study motion?

A lot of things move !

Simplest kind of motions is:

Motion along a straight line

that is, 1-dimensional motion.

1

Important concepts to learn:

Position
Displacement
Velocity
Acceleration

2

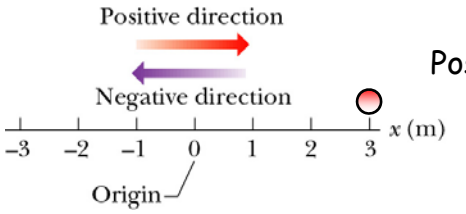
Position

What is motion?

Change of **position** over time

How to represent position along a straight line:

define: **x = 0** some position (Origin)
positive direction for x
length unit, e.g., meter

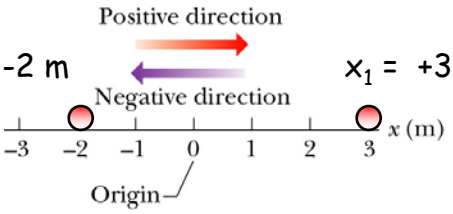


Position of ball: x = +3 m

3

Displacement

Displacement : Change in position



x_2 = -2 m

x_1 = +3 m

(Displacement) = $\Delta x = x_2 - x_1$ Δx =-2m-(+3m)= -5 m

+ or – sign represents direction

Length unit, e.g., meter

4

Average velocity, v_{avg}

(**Average velocity** between time t_1 and t_2)= v_{avg}

$$= \frac{x(t_2)-x(t_1)}{t_2-t_1} = \frac{x_2-x_1}{t_2-t_1} = \frac{\Delta x}{\Delta t} = \frac{\text{(Displacement)}}{\text{(Time change)}}$$

Unit : [Length unit]/[Time unit], e.g., m/s

5

Average speed, s_{avg}

(**Average speed** between time t_1 and t_2)= s_{avg}

$$= \frac{\text{(Total distance the object has traveled)}}{\text{(Time change)}}$$

Distance does not care about direction, unlike displacement

Distance & s_{avg} : always positive, no direction

In general, Distance ≠ Displacement

Average speed ≠ Average velocity

6

Example:
Displacement, distance, average velocity, average speed

X=0 km
t = 0 min

x = 50 km

7

Example:
Displacement, distance, average velocity, average speed

X=0 km

x = 50 km
t = 50 min

8

Example:
Displacement, distance, average velocity, average speed

X=0 km

x = 50 km
t = 50 min

9

Example:
Displacement, distance, average velocity, average speed

Between t1=0 and t2=100 min,

find displacement, distance, average velocity, average speed

X=20 km
t = 100 min

x = 50 km

10

Instantaneous velocity, or velocity

Instantaneous velocity, or simply, **velocity**
= Average velocity between t and t+Δt ,
where Δt is tiny

→ How fast at a given time t

11

Motion with a constant velocity, v

x(t) vs. t :

$$v = v_{avg} = \frac{x(t) - x_0}{t - 0} \rightarrow x(t) - x_0 = v\ t \rightarrow \boxed{x = x_0 + v\ t}$$

Instantaneous Speed, or Speed

(Instantaneous Speed) = (magnitude of instantaneous velocity)

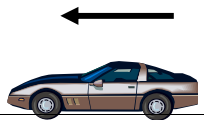
12

A car moves at a constant velocity -3 m/s.

Position at t=0 was -4.0 m

Find its position at t = 50 sec

v = - 3 m/s

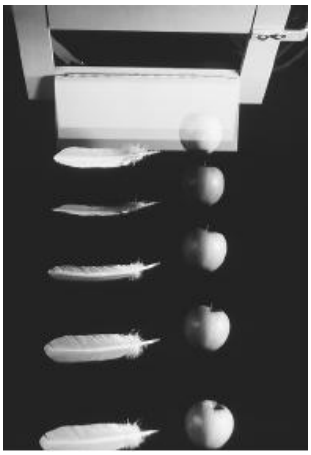


x0 = -4.0 m at t=0

13

Velocity changes !

→ Acceleration !



14

Average acceleration

(Average acceleration between time t_1 and t_2) = $\mathbf{a_{avg}}$

$$= \frac{v(t_2)-v(t_1)}{t_2-t_1} = \frac{v_2-v_1}{t_2-t_1} = \frac{\Delta v}{\Delta t} = \frac{\text{(Velocity change)}}{\text{(Time change)}}$$

Unit: (m/s)/s=m/s^2

15

Instantaneous acceleration

Instantaneous acceleration, or simply, **acceleration**

= Average acceleration between t and t+Δt ,

where Δt is tiny

16

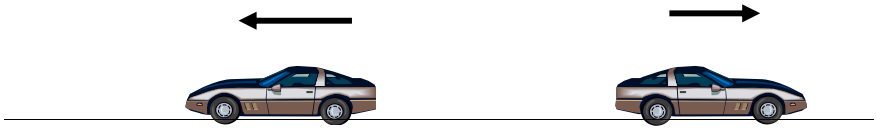
How to calculate velocity change: Careful with the velocity sign !!

What is average acceleration?

A) zero, (B) 20 m/s^2, (C) -20 m/s^2, (D) None of above

v2 = - 20 m/s

v1 = 20 m/s



t2 = 2 s

t1 = 0 s

17

iClicker Quiz: The acceleration between 0 s and 2 s is _____

(a) Positive (b) zero (c) negative (d) Not enough information

v2 = - 20 m/s

v1 = - 10 m/s

t2 = 2 s

t1 = 0 s

Example: Find average acceleration between 0 s and 2 s.

18

iClicker Quiz: The acceleration between 0 s and 2 s is _____

(a) Positive (b) zero (c) negative (d) Not enough information

v2 = + 20 m/s

v1 = - 10 m/s

t2 = 2 s

t1 = 0 s

Example: Find average acceleration between 0 s and 2 s.

19

iClicker Quiz: The acceleration between 0 s and 2 s is _____

(a) Positive (b) zero (c) negative (d) Not enough information

v2 = -20 m/s

v1 = - 10 m/s

t2 = 2 s

t1 = 0 s

Example: Find average acceleration between 0 s and 2 s.

20