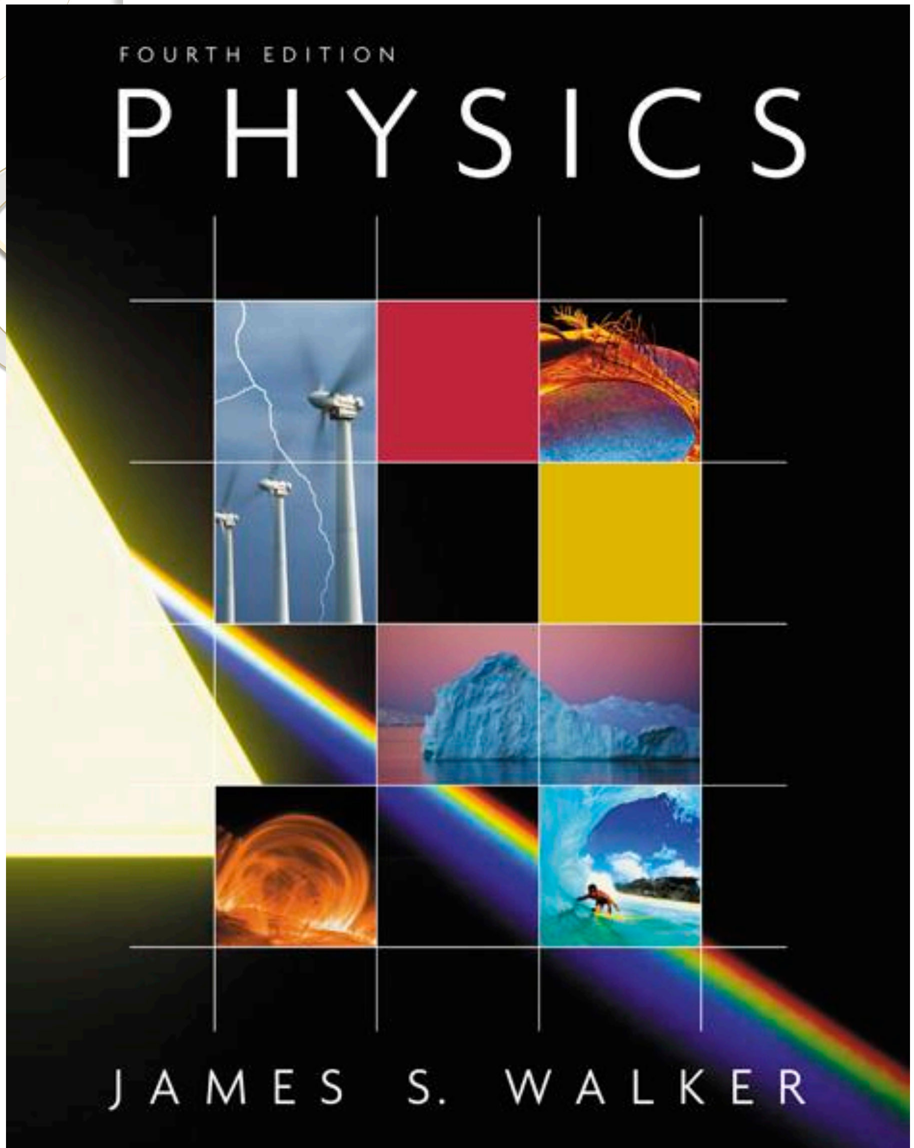


Lecture Outline

Chapter 2

Physics, 4th Edition

James S. Walker

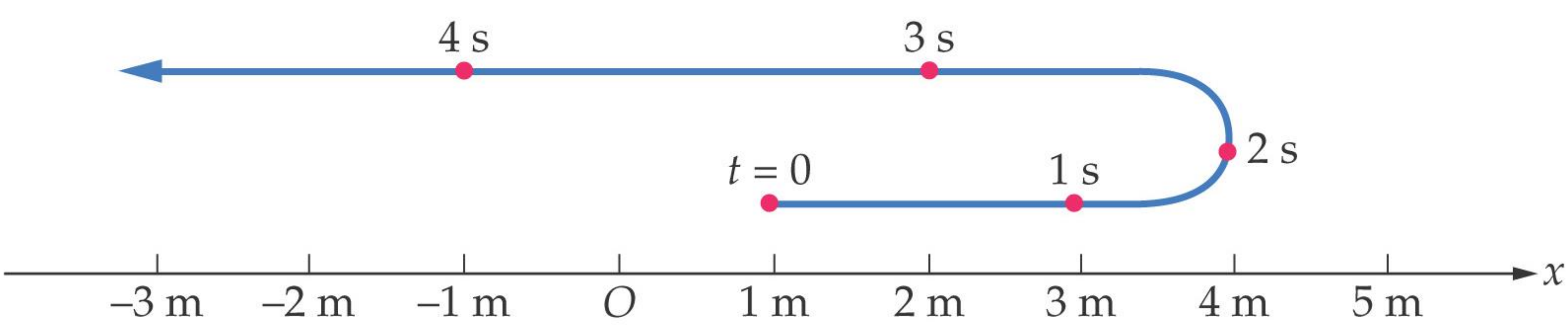
Resolve the last two slides

Chapter 2

The Mathmatic equation , Graphs.

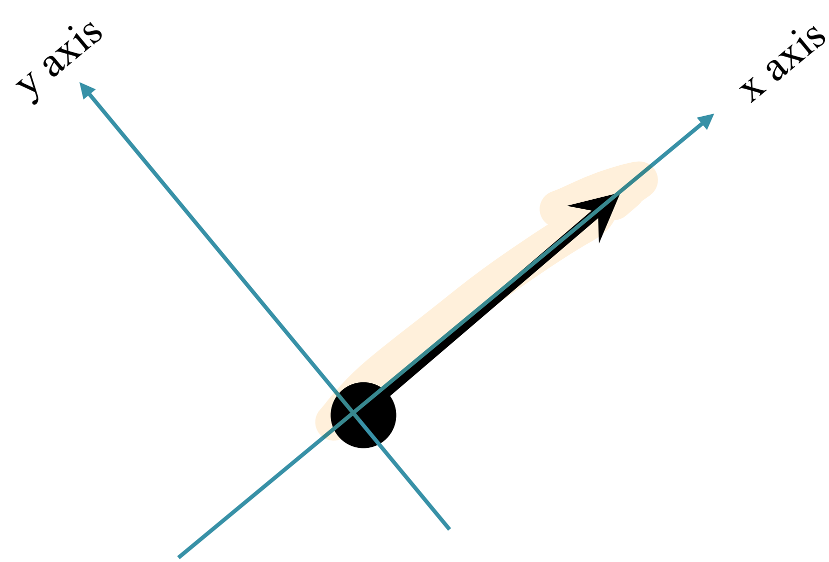
One-Dimensional Kinematics

straight line



One Dimensional Motion

- The one-dimensional motion is the motion of an object along a straight line.
- any object moving along a straight line can be considered as moving along the x-axis.



OBJECTIVES

Refrence point
How far from the RP
& Direction
length

- Defining a particles position
- Distance
- Displacement
- Average speed and velocity
- Acceleration
- Motion with constant acceleration
- Free fall

Definitions

من دون حفظ

- **Mechanics**

The study of motion

- **Kinematics**

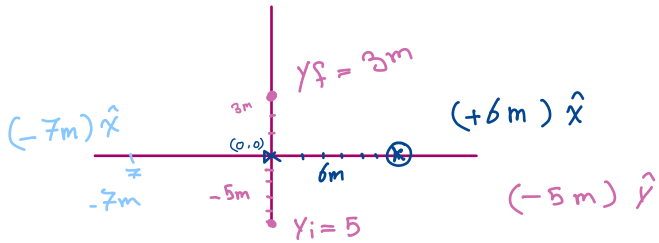
The mathematical description of motion in 1-D and 2-D motion

- **Dynamics**

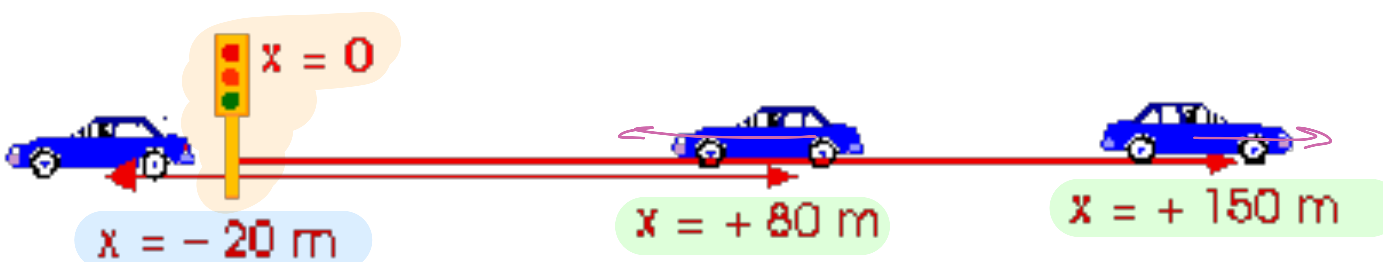
The study of the forces that cause motion

(2.1) Particle's Position

- Particle's Position is *the location of the particle with respect to a chosen reference point* that we can consider to be the origin of a coordinate system.

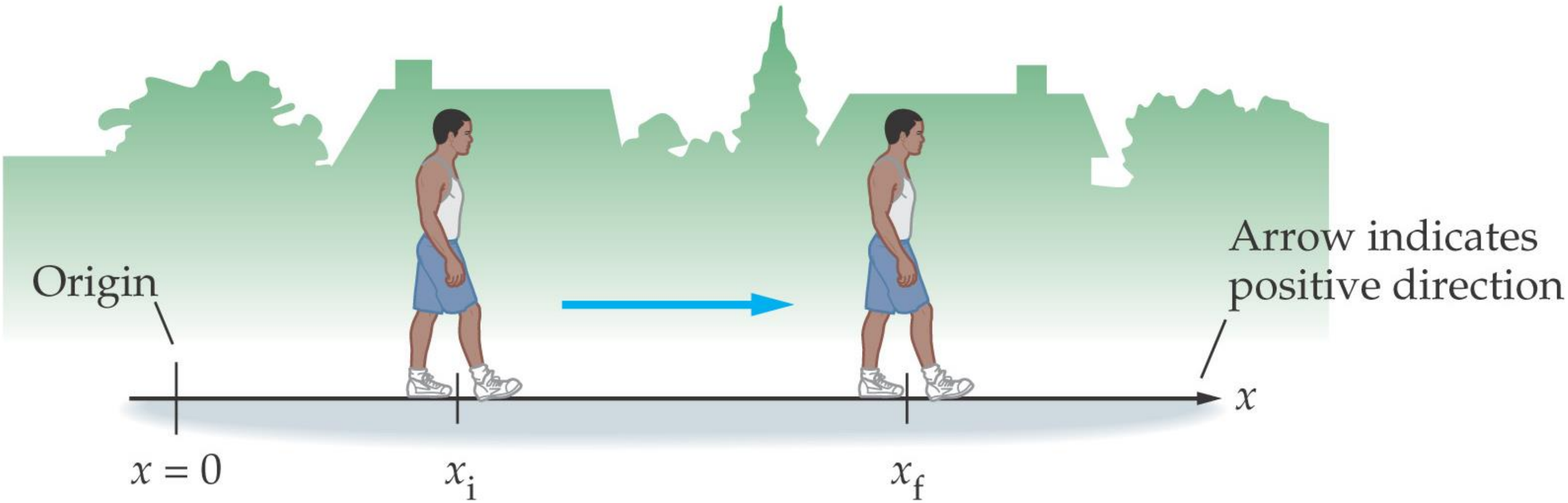


- **Positions to the right of the origin are positive.**
- **Positions to the left of the origin are negative.**



كمية متجهة و Vector Direction

Value + Direction $(+5m)\ \hat{x}$



(2.1) DISTANCE and DISPLACEMENT

$x_f = 11$ m $x_i = 6$ m $d = 11 - 6 = 5$

d scalar $d = x_f - x_i$

Both are fundamental

Distance: total length of travel How much u covered

SI unit is meter (m)

with unit fundamental scaler: enogh to describe # & unite

vector cuntity $\vec{d}$

$x_f = (+11)\,\hat{x}$

$x_i = (6m)\,\hat{x}$

$d = 11 - 6 = 5m$

d scalar

الإزاحة

Displacement of a particle $\Delta \mathbf{x}$ is defined as its *changed in position* in some time interval.

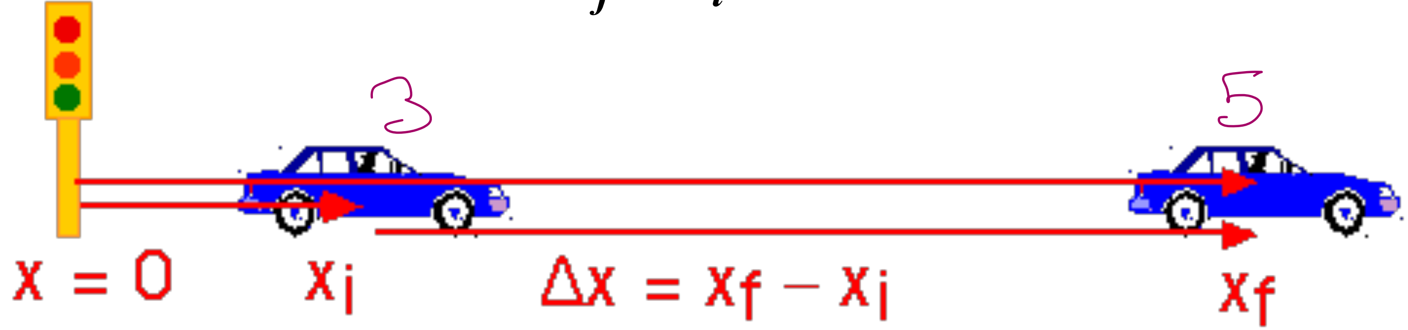
Δx

$x_f - x_i$

In other word; it is the difference between the final position x_f , and the initial position x_i .

$$\Delta x = x_f - x_i$$

Equation 2.1



$y_i = (-5m)\,\hat{y}$

$d = 3 - (-5) = 8m$

or $3+5=8$

$y_f = (+3m)\,\hat{y}$

$\vec{d} = 3 - (-5) = (+8m)\,\hat{y}$

$x_f = (-2m)\,\hat{x}$

$d = -2-(-7) = 5m$

$x_i = (-7m)\,\hat{x}$

$\vec{d} = -2-(-7) = (5m)\,\hat{x}$

Distance and Displacement

Distance

- Distance is always positive and tells how far something is from something else but does not tell us whether it is to the right or to the left.

- Units are important in Physics (and in all of Science). In the lab, we will usually measure distance or displacement in units of meters (m). Distance or displacement could also be measured in centimeters (cm) or kilometers (km) or even miles (mi).

Distance and Displacement

- **A displacement to the right will be a positive displacement.**

That is,

$$\Delta x > 0 \quad \text{since} \quad x_i < x_f$$

$i = -2$ $f = 4$

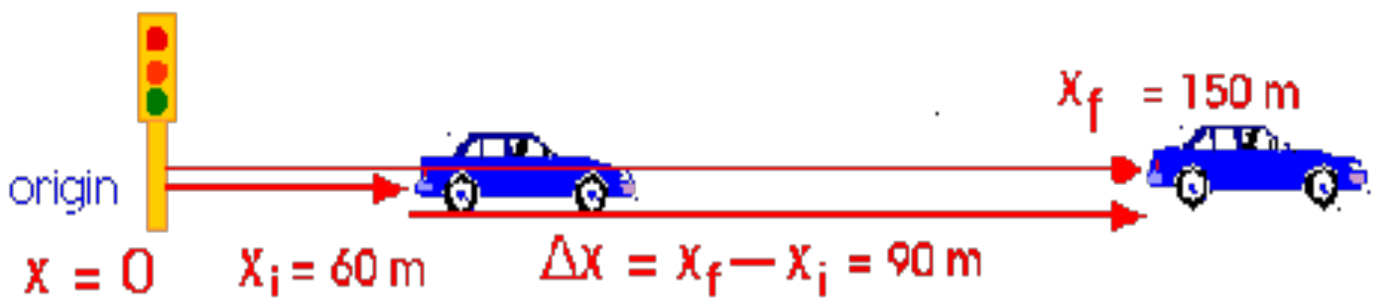
$\Delta x = f - i = 4 - (-2) = 6$

$f = -3$ 2

$-3 - 2 = -5$

For example, starting with x_i = 60 m and ending at x_f = 150 m, the displacement is

$$\Delta x = x_f - x_i = 150 \text{ m} - 60 \text{ m} = 90 \text{ m}$$



going to the Right

Distance and Displacement

start & end point

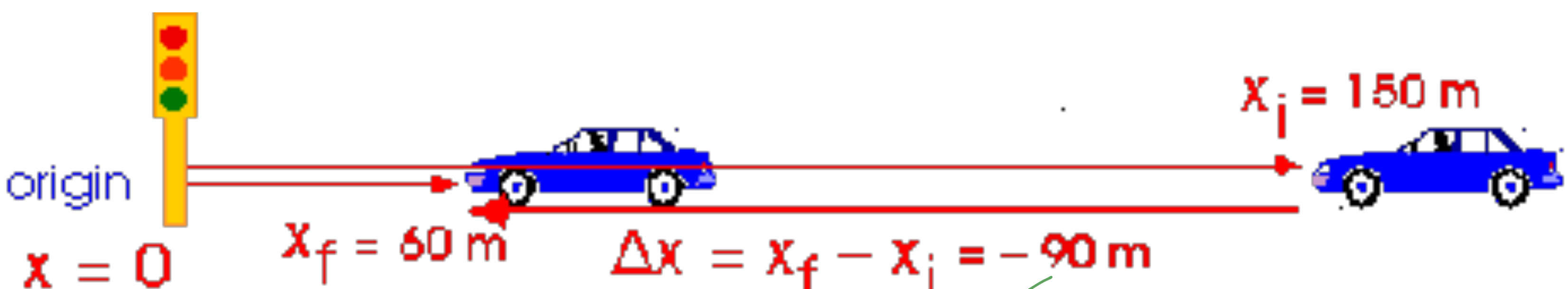
- **A displacement to the left will be a negative displacement.**

  That is,

$$\Delta x < 0 \quad \text{since} \quad x_i > x_f$$

For example, starting with x_i = 150 m and ending at x_f = 60 m, the displacement is

$$\Delta x = x_f - x_i = 60 \text{ m} - 150 \text{ m} = -90 \text{ m}$$



going to the left

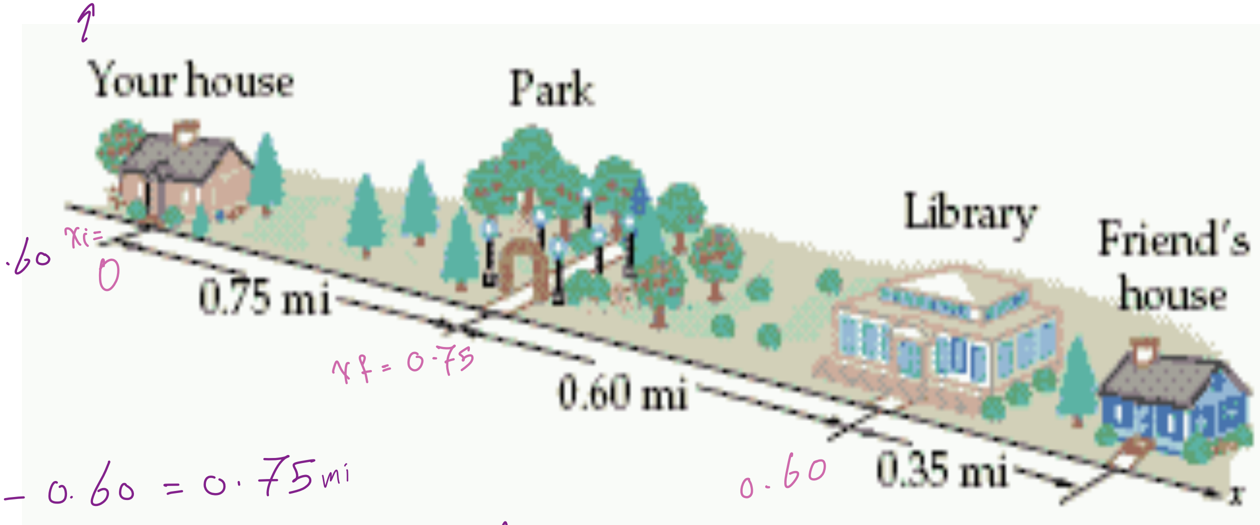
Problem 1

You walk from your home to the library, and then to the park.

a) What is the distance travelled?

b) What is your displacement?

The Refrence point (0,0)



$x_i = 0$

$x_f = 0.75$

0.60

1.35

$d = 0.75 + 0.60 + 0.60$

$= 1.95\text{ mi}$

$\vec{d} = 0.75 + 0.60 - 0.60 = 0.75\text{ mi}$

$\Delta x = x_f - x_i = 0.75 - 0 = 0.75\text{ mi}\ \hat{x}$

Answer: a) 1.95 mi

b) 0.75 mi

Problem 2

The two tennis players walk to the net to congratulate one another.

a) Find the distance travelled and the displacement of player A.

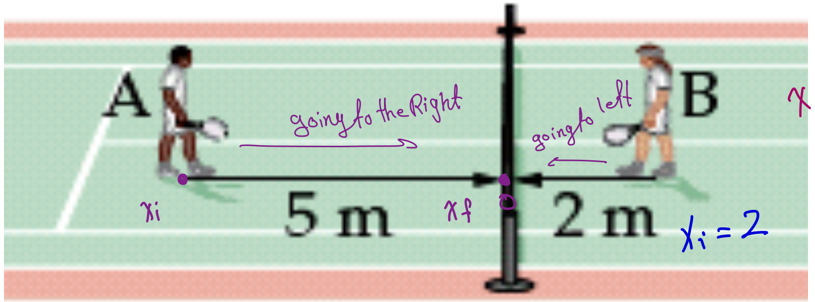
b) Repeat for player B.

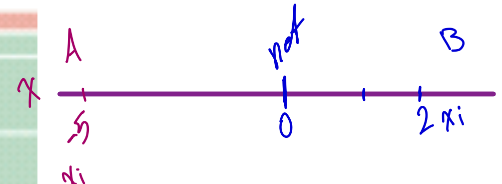
Player A

The player is to the left of origen

$d = x_f - x_i = 0 - (-5) = 5\,m$

$\vec{d} = x_f - x_i = 0 - (-5) = +5m\,\hat{x}$ going to right





$0 - (-5) = (5m)\,\hat{x}$

$\Delta x = 0 - (2) = -2$

$-2m\,\hat{x}$

player B:

$d = x_f - x_i = 0 - 2 = \boxed{2m}$

$\vec{d} = x_f - x_i = 0 - 2 = -2\,\hat{x}$

means that The player is going to the left

Answers: Player A Distance = 5 m

Displacement = $(+5\text{ m})\,\hat{x}$ going to the Right.

Player B Distance = 2 m

Displacement = $(-2\text{ m})\,\hat{x}$ going to the left

السرعة السرعة

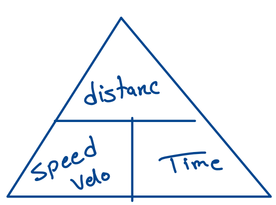
(2.2) Speed & Velocity

 # The <u>average speed</u> of an object over a given time interval is defined as the total distance traveled divided by the total time elapsed:

Scaler & Drived quantity

$$\text{Average speed} = \frac{\text{total distance}}{\text{total time}}$$

SI unit: meter per second (m/s)

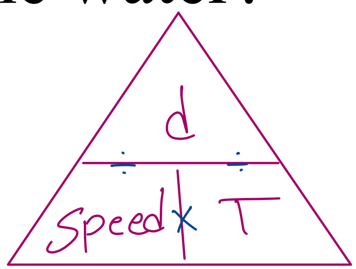


EXAMPLE 2-1

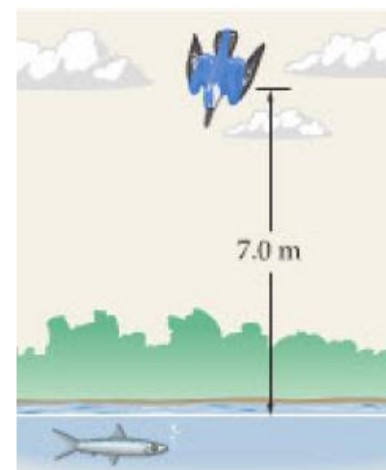
A kingfisher is a bird that catches fish by plunging into water from a height of several meters. If a kingfisher dives from a height of 7.0 m with an average speed of 4.00 m/s, how long does it take for it to reach the water?

Time

Ans: 1.8 s



$$\text{Time} = \frac{d}{\text{speed}} = \frac{7.0}{4.00} = 1.75\,s = 1.8\,s$$



Second from begin X 3600

convert to Secon /3600

Problem 9

Joseph DeLoach of the United States set an Olympic record in 1988 for the 200-m dash with a time of 19.75 seconds.

1 mile = 1609m

1. What was his average speed? 10.13 m/s

10.13

2. Give your answer in meter per second and miles per hour. L = d = 200m , Time = 19.75 S

1 $Speed_{avg} = \frac{d}{T} = \frac{200}{19.75} = 10.13\ m/S$

$10.13 \times \frac{3600}{1609}$

10.1

$\frac{10.13 \times 1 mail \times 3600}{1609 \times 1h}$

Answer: 10.13 m/s

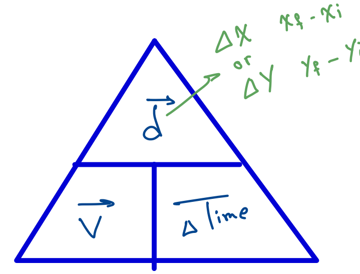
22.66 mi/h

22.7

AVERAGE VELOCITY

vector quntity

The **average velocity** during a time interval t is the displacement x divided by time t :



magnitude = speed = $|\vec{V}|$

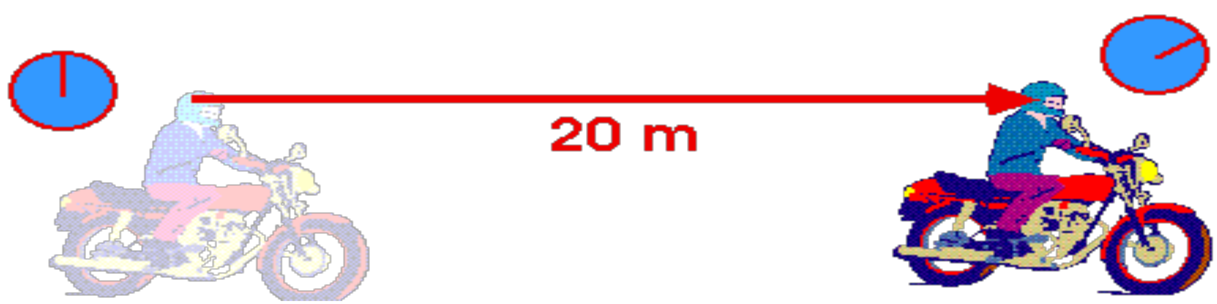
$\vec{V}$

SI Unit: meter per second (m/s)

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$

Equation 2.3

Speed & Velocity is also measured in km/h (and even in mi/hr).



$t_i = 0\,s$ $\quad x_i = 0$

$t_f = 10\,s$ $\quad x_f = (20m)\,\hat{x}$

$$\text{Speed} = \frac{d}{T} = \frac{20}{10} = 2\,m/s$$

$$\vec{V} = \frac{20 - 0}{10 - 0} = 2\,m/s\ \hat{x}$$

need direction

Example 2-2

ⓐ Spring avg Velo $= \frac{\vec{d}}{T} = \frac{50}{8} = 6.25\,m/s\,\hat{x}$

ⓑ $\text{Veloc}_{\text{walk}} = \frac{\vec{d}}{T} = \frac{0-50}{40} = -1.25\,m/s\,\hat{x}$

ⓒ $\frac{0-0}{48} = 0$

An athlete sprints 50.0 m in 8.00s, stops and the walks slowly back to the starting point in 40.0 s. If the sprint direction is taken to be positive, what are:

A)the average sprint velocity, B) the average walking velocity, and C)average velocity of the complete the round trip ?

① $\Delta V = \frac{\vec{d}}{t} = \frac{50}{8} = 6.25\,m/s$

$\Delta V = \frac{0-50}{40} = -1.25\,m/s$

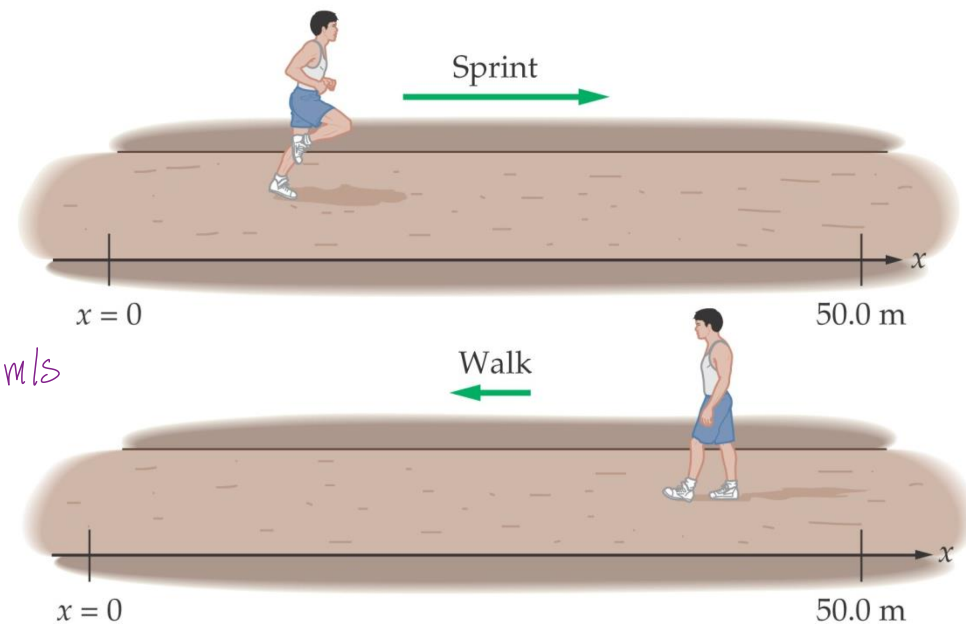
Ans:

A) 6.25m/s $\hat{x}$

B) -1.25m/s

C) 0

Speed $= \frac{100}{48} = 2.083\,m/s$



x_f $\vec{d} = x_f - x_i$ x_i

Sprint trip:

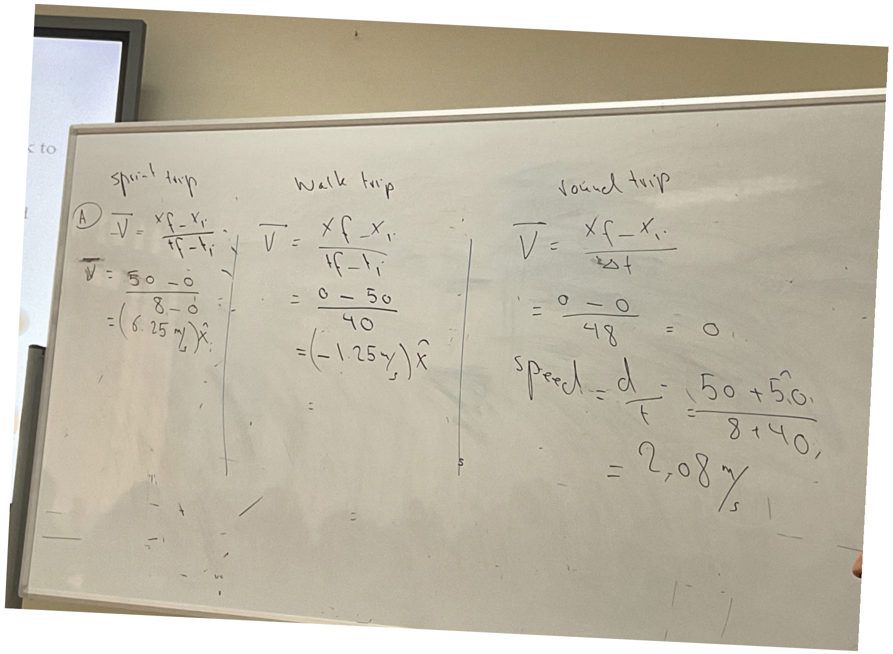
$$\vec{V} = \frac{\Delta x}{\Delta T}$$

$$\vec{V} = \frac{50 - 0}{8 - 0} = 6.25 \text{ m/s } \hat{x}$$

Walk trip

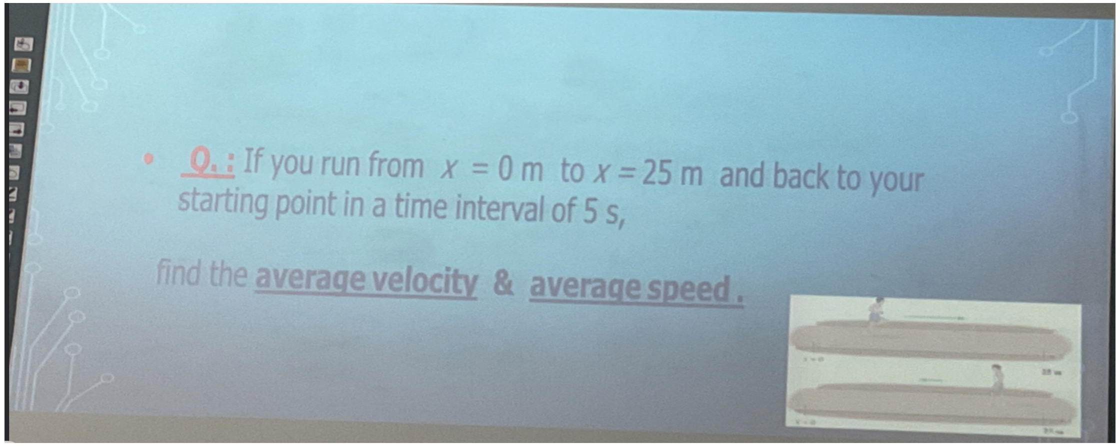
$$\vec{V} = \frac{0 - 50}{40} = -1.25 \text{ m/s } \hat{x}$$

speed	velocity $\vec{V}$
Drive	Drive
scalar	vector
$\frac{d}{t}$	$\frac{\Delta x}{\Delta t} = \frac{\vec{d}}{\text{time}}$
m/s	m/s



- **Q. :** If you run from $x = 0$ m to $x = 25$ m and back to your starting point in a time interval of 5 s,

find the **average velocity** & **average speed .**



$$\text{Speed}_{avg} = \frac{d}{T} = \frac{25 + 25}{5} = 10 \, m/s$$

$$\text{Velocity} = \frac{x_f - x_i}{t_f - t_i} = \frac{0 - 0}{5} = 0$$

Speed & Velocity

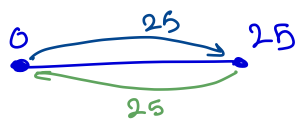
- **Q. :** If you run from $x = 0$ m to $x = 25$ m and back to your starting point in a time interval of 5 s,

find the **average velocity** & **average speed .**

Ans. :

1 run

2 run



$25 + 25 = 50$

$$\vec{v}_{avg} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$

The average Velocity is zero.

The average speed is 10 m/s. $= \frac{50}{5} =$

10 m/s

$\vec{V}$

Vector

Speed

+ unit

chang in speed

Direction

change in it

or Both

We have $\vec{a}$

acceleration

When we have change in velocity, then we have Acceleration

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

Drived

(2.5) Acceleration

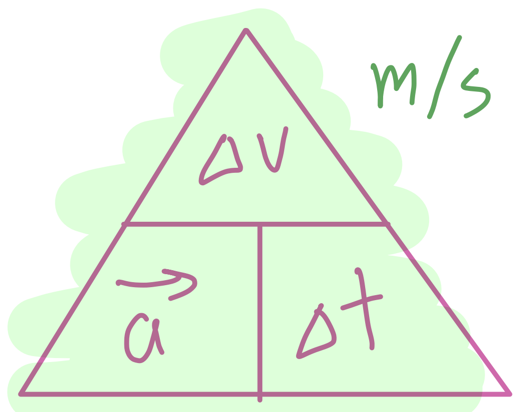
vector quantity

We are often interested in how fast the velocity is changing. This is the acceleration.

Acceleration :-is a change of velocity divided by a change of time.

$$\vec{a}_{avg} = \frac{\Delta \vec{v}}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

Equation 2.5



m/s

s

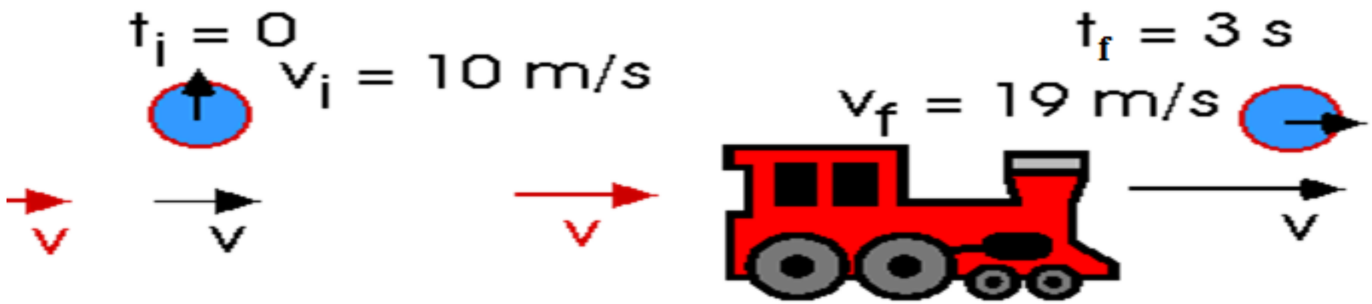
= SI unit: m/s^2

could be kg/s^2

Acceleration

Vector
Direction

Example: **Find the acceleration from the figure below .**



$$a = \frac{\Delta V}{\Delta t} = \frac{V_f - V_i}{T_f - T_i} = \frac{19 - 10}{3 - 0} = 3 \ m/s^2 \ \hat{x}$$

Ans:

$$\vec{a} = \frac{\Delta v}{\Delta t} = \frac{(19 - 10) m/s}{3 \, s} = \frac{9 \, m/s}{3 \, s} = 3 \, \frac{m/s}{s}$$

$$a = 3 \, m/s/s = 3 \, m/s^2 \quad \hat{x}$$

Right of
the oragin

Exercise

$a = \frac{\Delta v}{\Delta t}$

$\Delta t = \frac{\Delta v}{a} = \frac{v_i - v_f}{a} = \frac{\frac{150 \times 10^3}{3600} - 0}{5.6} = 7.44\,s$

- An airplane has an average acceleration of 5.6m/s^2. Starting from rest, how long it takes the airplane to reach 150 km/h?

$v_i = 0$ time = ? $\vec{a} = 5.6\ m/s^2$

(**<u>Ans.</u>** 7.44 s)

V_f = speed = 150 Km/h

$\frac{Km}{s}$

$V_f = 41.7\ m/s = \frac{150 \times 1000\ m}{3600\ s}$

$\text{Time} = \frac{41.7 - 0}{5.6} = 7.4\ s$

2sf

speed is decreasing
Decceleration
V = positive
a = neg

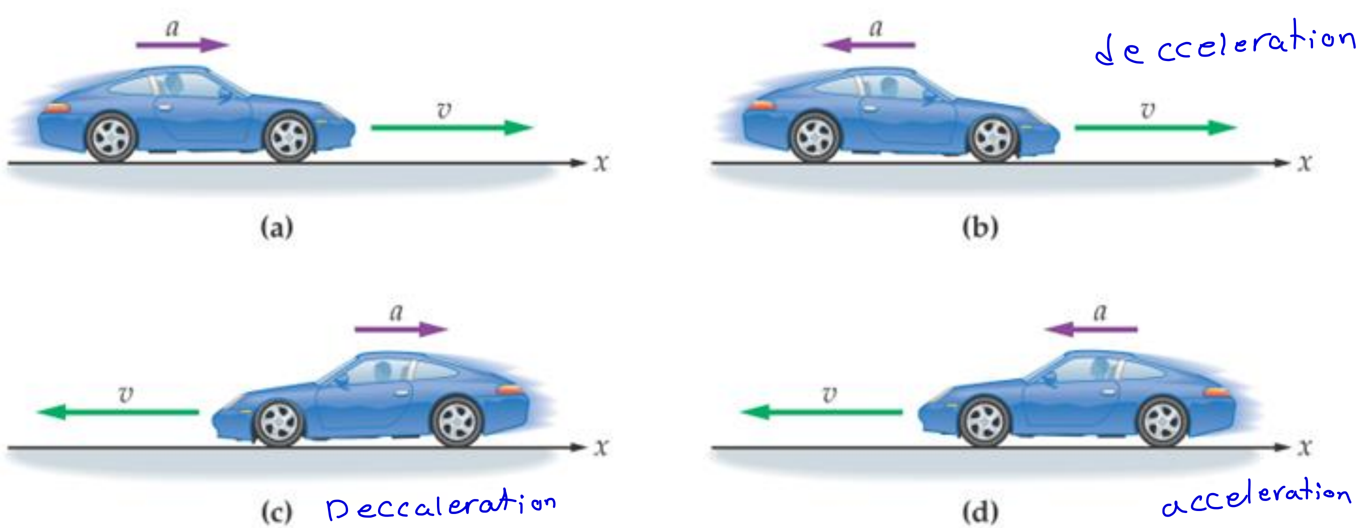
(2.5) Acceleration

Acceleration (increasing speed) and deceleration (decreasing speed) should not be confused with the directions of velocity and acceleration.

In Fig (a) and (d) speed increases

In Fig (b) and (c) speed decreases

acceleration

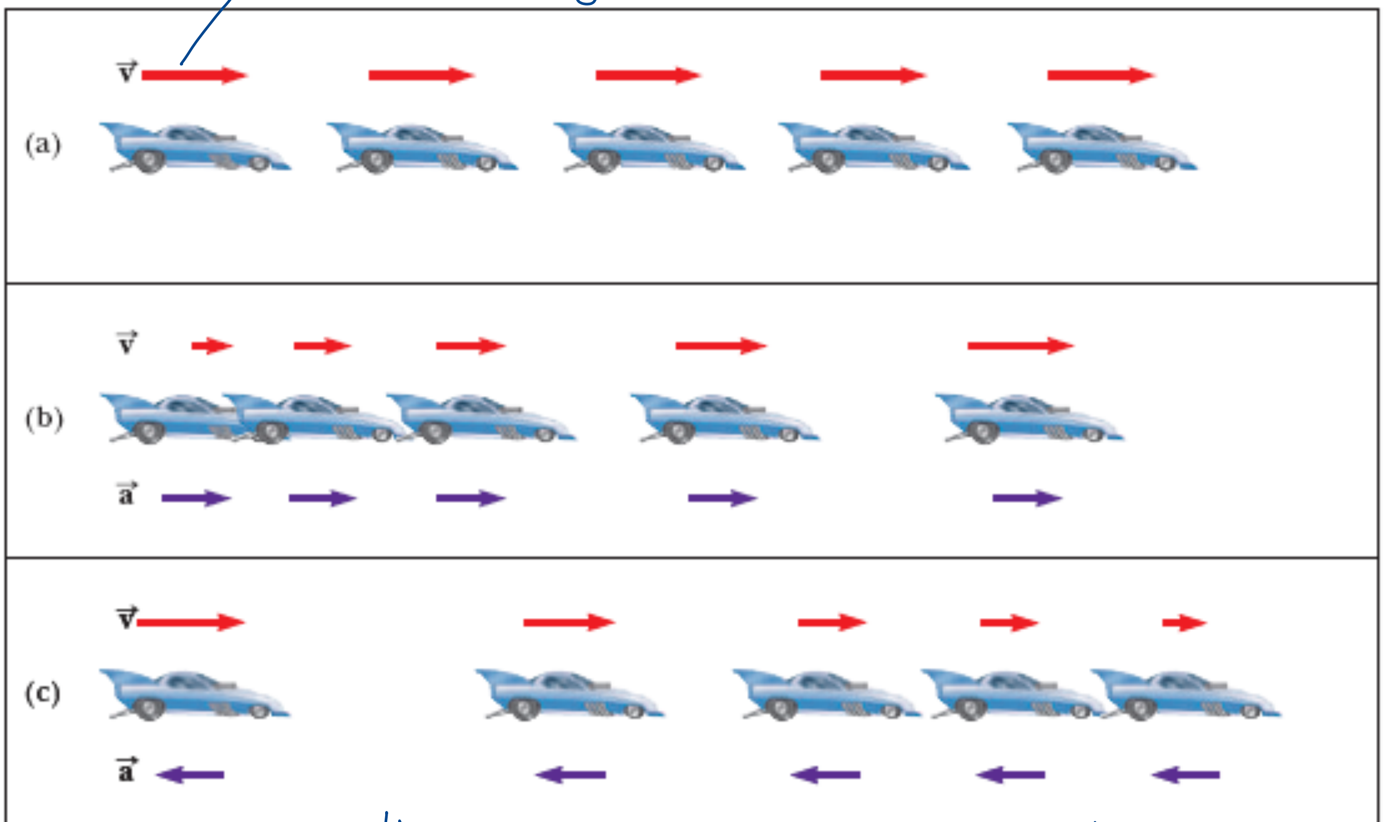


$\overrightarrow{acc}$	$\overrightarrow{Decel}$
* increas in speed	* Decreas in speed
$\frac{+\vec{v}}{+a}$	$\frac{-\vec{v}}{+a}$
$\frac{-\vec{v}}{-a}$	$\frac{+\vec{v}}{-a}$
Same Direction	opposit Direction

MOTION DIAGRAMS

same speed {constant}

velocity: same speed, Direction (positive, Right x-axic)



Constant Velocity

a = 0

$v_f > v_i$

Varying Velocity

a > 0

acceleration

$V_f = 10$

$V_i = 20$

$10 - 20 = -10$

Varying Velocity

a < 0

Deceleration

Deccaleration: either by saing Decreasing in speed

or v & a are in oppisite Direction.

Example 2.4

A ferry makes a short run between two docks one in Anacortes. Washington, the other on Guemes Island. As the ferry approaches Guemes island(travelling in positive x-direction, its speed is 7.4 m/s. V_i

(a) If the ferry slows to a stop ($V_f = 0$) in 12.3 s, what is its average acceleration? $a = \frac{\Delta V}{\Delta T} = \frac{0-7.4}{12.3} = -0.6$

(b) As the ferry returns to the Anacortes dock, its speed is 7.3 m/s. If it comes to rest in 13.1 s, what is its average acceleration?

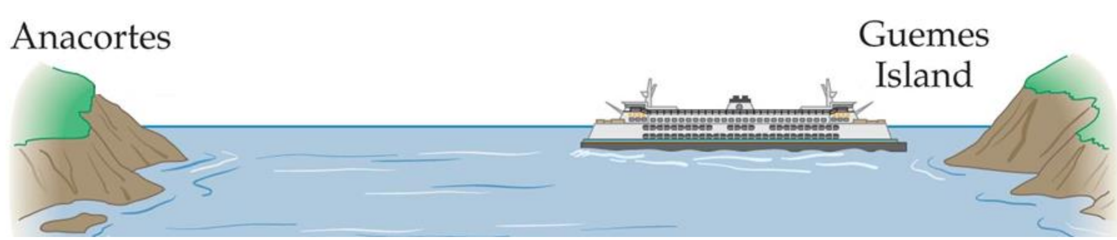
going to left

$a = \frac{V}{T} = \frac{0-(-7.4)}{12.3} = 0.56 m/s^2$

Ans:

a) - 0.6 m/s^2

b) 0.56 m/s^2 $\rightarrow \frac{V}{T} =$



(a) $V_f = 0$, $V_i\ (7.4\ m/s)\hat{x}$

$\Delta t = 12.3\ s$

$$\vec{a} = \frac{V_f - V_i}{t_f - t_i} = \frac{0 - (7.4)}{12.3} = (-0.6\ m/s)\hat{x}$$

$\frac{+v}{-a}$ = Decceleration

(B) Speed = 7.3 m/s

$V_f = 0$, $V_i\ (-7.3\ m/s)\hat{x}$

$$\vec{a} = \frac{V_f - V_i}{t_f - t_i} = \frac{0 - (-7.3)}{13.1}$$

$f \leftarrow i$

negative in x acies

$= 0.56\ m/s\ \hat{x}$ Deccaleration

$\frac{-v}{+a}$

(2.5) MOTION WITH CONSTANT ACCELERATION

using these equation when Acceleration is constant

increasing the velocity in

$X_f = X_i + \vec{V}_{avg} \cdot t$ ①

1. Velocity as a function of time

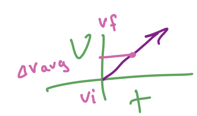
$V_f = V_i + at$ ②

$$\mathbf{v} = \mathbf{v_0} + \mathbf{a\,t} \qquad \textbf{(for constant a)}$$

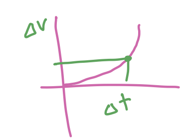
2. Initial, Final and average velocity

$$\vec{v}_{avg} = \frac{\mathbf{v_0} + \mathbf{v}}{2} \qquad \textit{(for constant a)}$$

constant linear



$v_{avg} = \frac{v_i + v_f}{2}$



3. Position as a function of time and velocity

$$x_f = x_{0_i} + \frac{1}{2}(v_0 + v)t$$

4. Position as a function of time and acceleration

$$x = x_0 + v_0 t + \frac{1}{2}at^2$$

$X_f = X_i + V_i t + \frac{1}{2}at^2$ ③

5. Velocity as a function of position

$$v_f^2 = v_{0_i}{}^2 + 2a(x - x_0) = v_0{}^2 + 2a\Delta x$$

$v_f^2 = v_i^2 + 2a\Delta x$ ④

1

$$\vec{V}_{avg} = \frac{x_f - x_i}{t_f - \cancel{t_i}} \Longrightarrow x_f = x_i + V_{avg}\,t$$

2

$$\vec{a} = \frac{v_f - v_i}{t_f - \cancel{t}} \Longrightarrow v_f = v_i + at$$

3 $x_f = x_i + v_i t + \frac{1}{2}at^2$

4 $v_f^2 = v_i^2 + 2a\Delta x$

5 $V_{avg} = \frac{v_i + v_f}{2}$

$v_f = v_i + at$

$v_f^2 = v_i^2 + 2a\Delta x$

$x_f = x_i + v_{avg}\,t$

$x_f = x_i + v_i t + \frac{1}{2}at^2$

(2.5) MOTION WITH CONSTANT ACCELERATION

$V_f = V_i + at$, $V_f^2 = V_i^2 + 2a\Delta x$, $x_f = x_i + V_i t + \frac{1}{2}at^2$, $x_f = x_i + V_{avg} t$

Equations of Motion at Constant Acceleration

$x_f = x_i + V_{avg} t$ $\quad V_f = V_i + at$ $\quad V_{avg} = \frac{V_i + V_f}{2}$

$x_f = x_i + V_i t + \frac{1}{2}at^2$ $\quad V_f^2 = V_i^2 + 2a\Delta x$

1. $\Delta x = \frac{1}{2}(v_i + v_f)\,t$ ………… missing *a*
2. $v_f = v_i + at$ ………… missing Δx
3. $v_f^2 = v_i^2 + 2a\,\Delta x$ ………… missing *t*
4. $\Delta x = v_i t + \frac{1}{2}at^2$ ………… missing v_f
5. $\Delta x = v_f t - \frac{1}{2}at^2$ ………… missing v_i

Example 2-5

$x_f = x_i + v_i t + \frac{1}{2}at^2$

$x_f = x_i + v_{avg} t$

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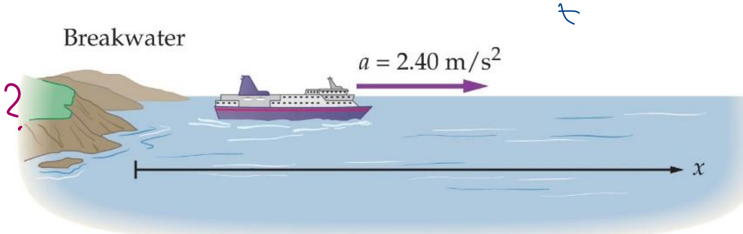
- A boat moves slowly inside a marina (So as not to leave a wake) with a constant speed of 1.50 m/s (v_i). As soon as it passes the breakwater, leaving the marina, it throttles up and accelerates at 2.40 (a) m/s2.

$V_f = V_i + at$

$1.5 + 2.4 \times 5 =$

a) How fast (v_f) is the boat moving after accelerating for 5.00 s (t)?

b) How far has the boat traveled?



$|V_i| = 1.50\ m/s$ $\quad |\vec{a}| = 2.40\ m/s$ $\quad |V_f| = ?$

$t = 5s$

Ans. a)13.5 m/s

b) 37.5m

(a)

$V_f = V_i + at$

$1.50 + (2.40 \times 5)$

$= 13.5\ m/s$

(B) Δx ?

$x = ?$

$x_f = \underset{0}{\underline{x_i}} + v_i t + \frac{1}{2}at^2$

$\Delta x = (1.50 \times 5) + (\frac{1}{2}(2.4)(5^2))$

67.5

$= 37.5\ m$

acceleration

$\vec{a}$ = constant

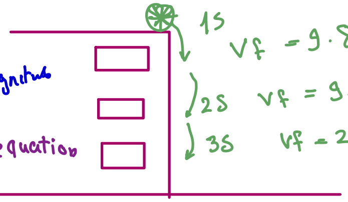
$\vec{a} = g = 9.81\ m/s^2$ magnitude

$-9.81\ \hat{y}$ → Five equation

same equation in { constant acceleration }

replace a by g

2.7 Freely Falling Objects



- **Free fall** is the motion of an object subject only to the influence of gravity. The acceleration due to gravity is a constant, g.
- All objects in free fall accelerate with the **same acceleration** (regardless of their weight).

$a = \frac{V}{t} = \frac{\vec{d}}{t^2}$

- The object can be going up or down, it is still in free fall!
- Free fall acceleration $g \approx 9.81\ m/s^2$. The direction of g is **always downwards** (towards earth's center).
- The same equations of motion at constant acceleration apply, using g as the acceleration.
- If downward is chosen as the $+y$ direction, then $a = +g$; if downward is chosen as the $-y$ direction, then $a = -g$ (this is usually our choice for the sign).

TABLE 2–5 Values of g at Different Locations on Earth (m/s^2)

Location	Latitude	g
North Pole	90° N	9.832
Oslo, Norway	60° N	9.819
Hong Kong	30° N	9.793
Quito, Ecuador	0°	9.780

2.7 Freely Falling Objects

if there is another force or not

frection
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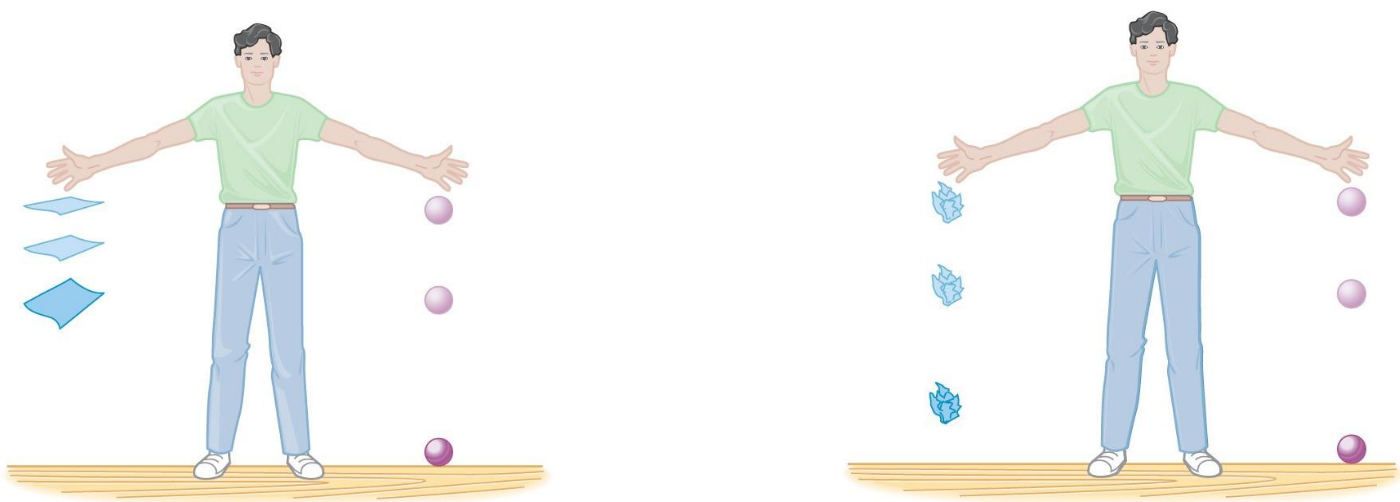
An object falling in air is subject to air resistance (and therefore is not freely falling).

contact air resisdence



(a) (b)

Free fall equation

$x_i = x_0$

$y_i = y_0$

$V_i = V_0$

$t_f = t$

$y_f = y$

$$V = \sqrt{2gx}$$

V is velocity

'X' is the position

'g' is acceleration due to gravity

Numerical value of

$$g = 9.81\, m/s^2 \; or \; 981\, cm/s^2$$

2 is constant

Also

$$x = 1/2gt^2$$

x—position

g---gravity

t---time

$V = \sqrt{2 \cdot g \cdot \frac{1}{2} g \cdot t^2}$

Example 10

$V_f = V_i + gt$

$x_f = x_i + V_{avg} t$

$x_f = x_i + V_i t + \frac{1}{2} a t^2 = 0 = 3 + 0 + 1/2\,(9.81) \times t^2$

$V_f^2 = V_i^2 + 2a\Delta x$

$V_i = 0$ $X = 3$

A person steps off the end of a 3m high, diving board and drops to the water below .

a) how long does it take for the person to reach the water?

b) What is the persons speed on entering the water?

(a) $y_f = y_i + v_i t + 1/2\, a t^2$ $V = \sqrt{2 g t^2}$

$0 = 3 + 0 + 1/2(-9.81) t^2$

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

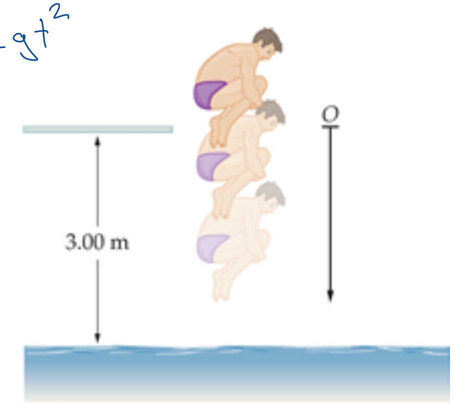
$-3 = (-4.905) t^2$

$$y = y_0 + v_0 t + ½\, a t^2$$

$t^2 = \frac{-3}{-4.905} = \sqrt{3/4.9} =$

$$v = v_0 + a t$$

0=7825



$x = \frac{1}{2} g t^2$

$\sqrt{\frac{x \times 2}{g}}$

Ans:

a) 0.782 s

b) 7.67 m/s $\hat{y}$

(a) $= X = \frac{1}{2} g t^2$

$V_f = V_i + gt$

$9.81(0.782) = 7.67$ m/s

$\frac{2 \cdot X}{g} = t^2$

$= \sqrt{}$

$x_i = 0$ $a = 1.9\ m/s^2$

$v_i = 0$ 5.2 Same speed $\vec{v}$ = constant end

$a=0$

This is a for the first 5.2 sec

Exercises

Problem 33: At the starting gun, a runner accelerates at 1.9 m/s^2 for 5.2 s. The runner's acceleration is zero for the rest of the race. What is the speed of the runner (a) at 2.0 s, and (b) at the end of the race.

(a) $v_f = v_i + at$

$0 + (1.9)(2)$

$= 3.8\ m/s$

(B) $v_f = v_i + at$

$0 + (1.9)5.2$

$= 9.88\ m/s^2$

$9.9\ m/s^2$

Answers (a) 3.8 m/s

(b) 9.9 m/s

Problem 43: Landing with a speed of 81.9 m/s (v_i), travelling due south, a jet comes to rest ($v_f = 0$) in 949 m. Assuming the jet slows with constant acceleration, find the magnitude and direction of acceleration.

check Record

Answer 3.53 m/s^2 to the North

$v_f^2 = v_i^2 + 2a\Delta x$ (949)

$$\vec{a} = \frac{v_f^2 - v_i^2}{2\Delta x} = \frac{0^2 - 81.9^2}{2(949)} = -3.53\ m/s^2$$

Summary of Chapter 2

- Distance: total length of travel
- Displacement: change in position
- Average speed: distance / time
- Average velocity: displacement / time

Summary of Chapter 2

- Average acceleration: change in velocity divided by change in time

- Deceleration: velocity and acceleration have opposite signs

- Constant acceleration: equations of motion relate position, velocity, acceleration, and time

- Freely falling objects: constant acceleration

  $g = 9.81\ \text{m/s}^2$