Displacement and Velocity

Chapter 2-1

- As any object moves from one position to another, the length of the straight line drawn from its initial position to the object's final position is called **displacement**.
- Point A directly to Point B
- **Distance** is the total amount traveled. Very difficult to measure

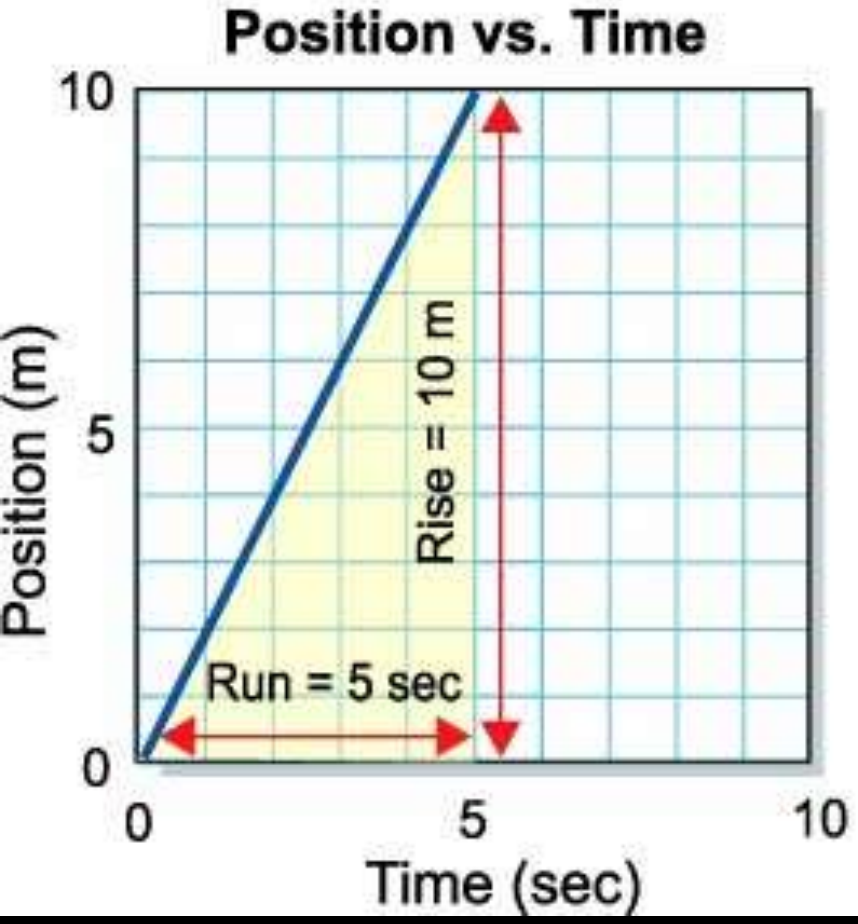
- If displacement is **positive**, the object moves to the right.
- If the displacement is **negative**, the object moves to the left.

- velocity = displacement / time
- Units are meters/second (**m/s**)
- Average velocity does not tell you speed or velocity at each moment.
- Can be positive or negative depending on direction moved.
- Time can never be negative!

- Velocity is not the same as speed.
- Velocity gives both direction and magnitude or size while speed only gives size - no direction
- Average speed = distance/time

- If you graph distance on the y-axis and time on the x-axis, the slope of the line is equal to the average speed.
- Slope=rise=distance= speed
  run time

Position vs. Time Graph



$$\text{Slope} = \frac{\text{rise}}{\text{run}} = \frac{10\text{ m}}{5\text{ sec}} = 2\text{ m/sec}$$

The slope of position vs. time is the **speed.**

Graphs

- The slope and shape of a graph describes the object's motion.

- To determine velocity at any instant it is called **instantaneous speed**.
- Radar Gun can measure this

Solving Problems

Identify what the problem is looking for

Calculating gravitational forces

Use the following information to calculate the force of gravity between Earth and the moon.
Mass of Earth: 5.97×10^{24} m Mass of moon: 7.34×10^{22} kg Distance between centers of Earth and moon: 3.84×10^{8} m

Identify the information you are given

1. Looking for: You are asked for the force of gravity between Earth and the moon.

2. Given: You are given their two masses in kilograms and the distance between their centers in meters.

Identify useful relationships

3. Relationships: $F_g = G\frac{m_1 m_2}{r^2}$

Solve the problem

4. Solution:

$$F_g = (6.67\times10^{-11}\ \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2})\frac{(5.97\times10^{24}\ \text{kg})(7.34\times10^{22}\ \text{kg})}{(3.84\times10^{8}\ \text{m})^2}$$

$$F_g = (6.67\times10^{-11}\ \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2})\frac{(4.38\times10^{47}\ \text{kg}^2)}{(1.47\times10^{17}\ \text{m}^2)} = 1.99\times10^{20}\ \text{N}$$

Your turn...

a. Calculate the force of gravity on a 50-kilogram person on Earth (6.38×10^{6} m from its center). **Answer:** 489 N
b. Calculate the force of gravity on a 50-kilogram person on the moon (1.74×10^{6} m from its center). **Answer:** 81 N

Practice your problem-solving skills

- #1. Heather and Matthew walk eastward with a speed of 8 m/s. If it takes them 534 seconds to walk to the store, how far have they walked?
- Knowns? What do you know? Write it down.
- Unknown? What do you want to know?
- Equation? Write the equation you'll use.
- Work the problem.

Chapter 2-2

Acceleration

- Acceleration is the measure of how fast something speeds up or slows down.
- a = acceleration
- vf = final velocity
- vi = initial velocity

- $a = (v_f - v_i)/t$
- Si Units for Acceleration is m/s^2
- Velocity units are m/s
- Time = seconds
- Time can NEVER be negative

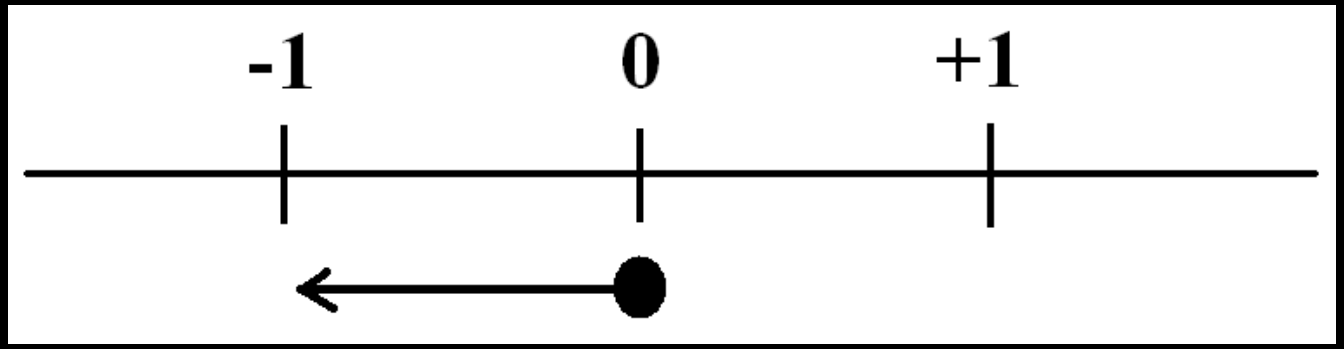
- #1. As the shuttle comes to a sudden stop, it accelerates at -4.1m/s^2 as it slows from 9 m/s to 0 m/s in what time?
- Knowns?
- Unknown?
- Equation?
- Answer?

Vector versus Scalar

- A **vector** has a size and a direction
- Example – 20 m/s due North
- A **scalar** has only a size - no direction
- Example – 20 m/s

Accelerating Versus Decelerating

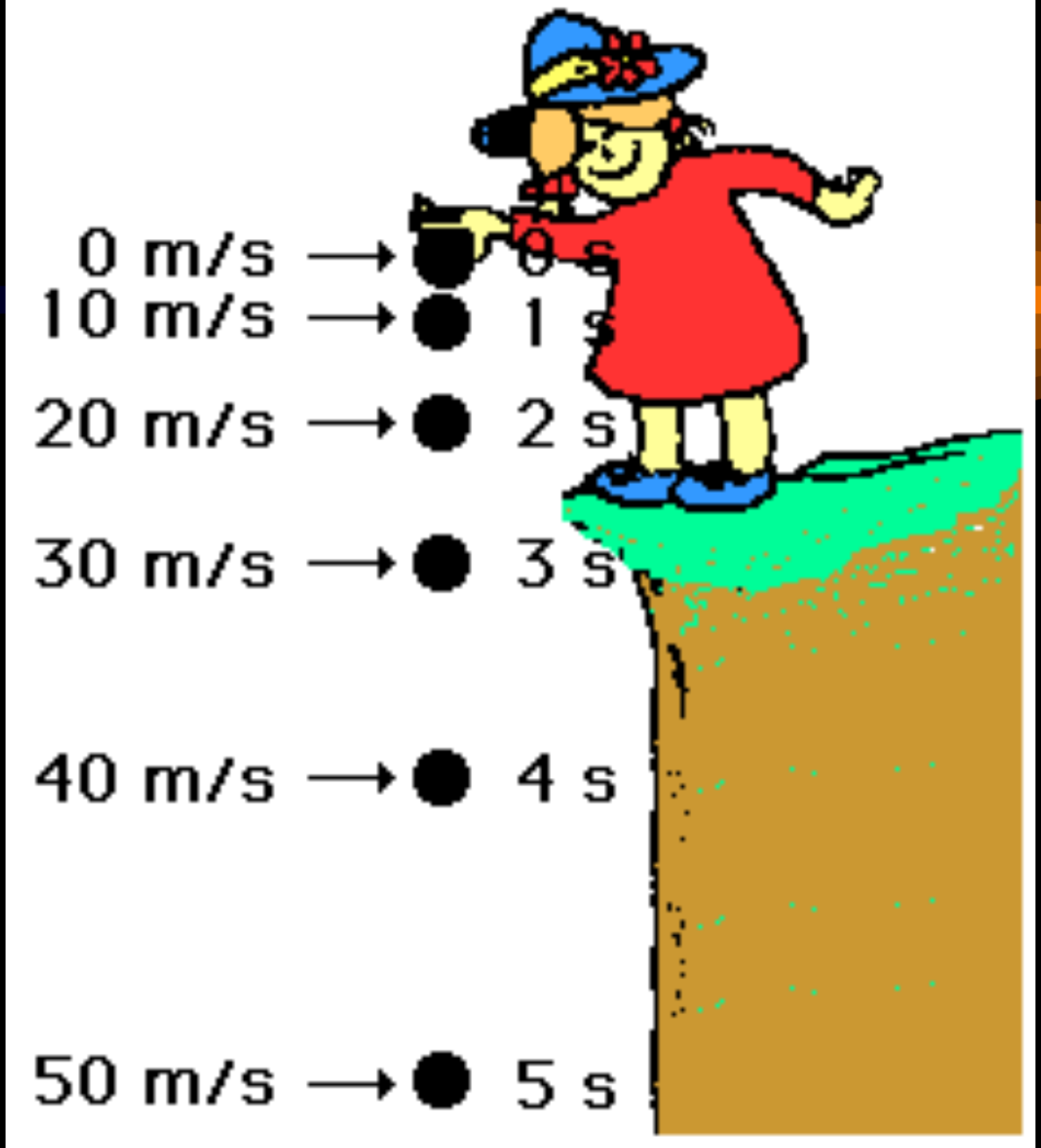
- A negative acceleration doesn't always mean the object is slowing down. It could be moving in the negative direction.



Chapter 2-3

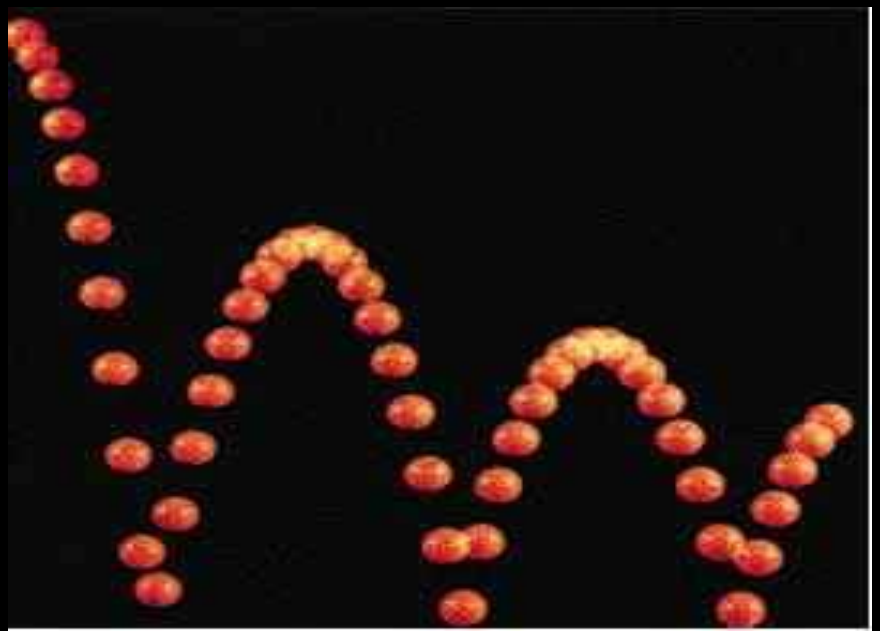
Falling Objects

- Freely falling objects have constant acceleration.
- This is only true with the absence of air resistance.
- The free-fall acceleration is denoted with the symbol g and is equal to **$9.8 m/s^2$**.


0 m/s → 0 s
10 m/s → 1 s
20 m/s → 2 s
30 m/s → 3 s
40 m/s → 4 s
50 m/s → 5 s

- Free Fall acceleration is directed downwards, toward the center of the Earth.
- Since the downwards direction is **negative**, the acceleration due to gravity is also considered negative.

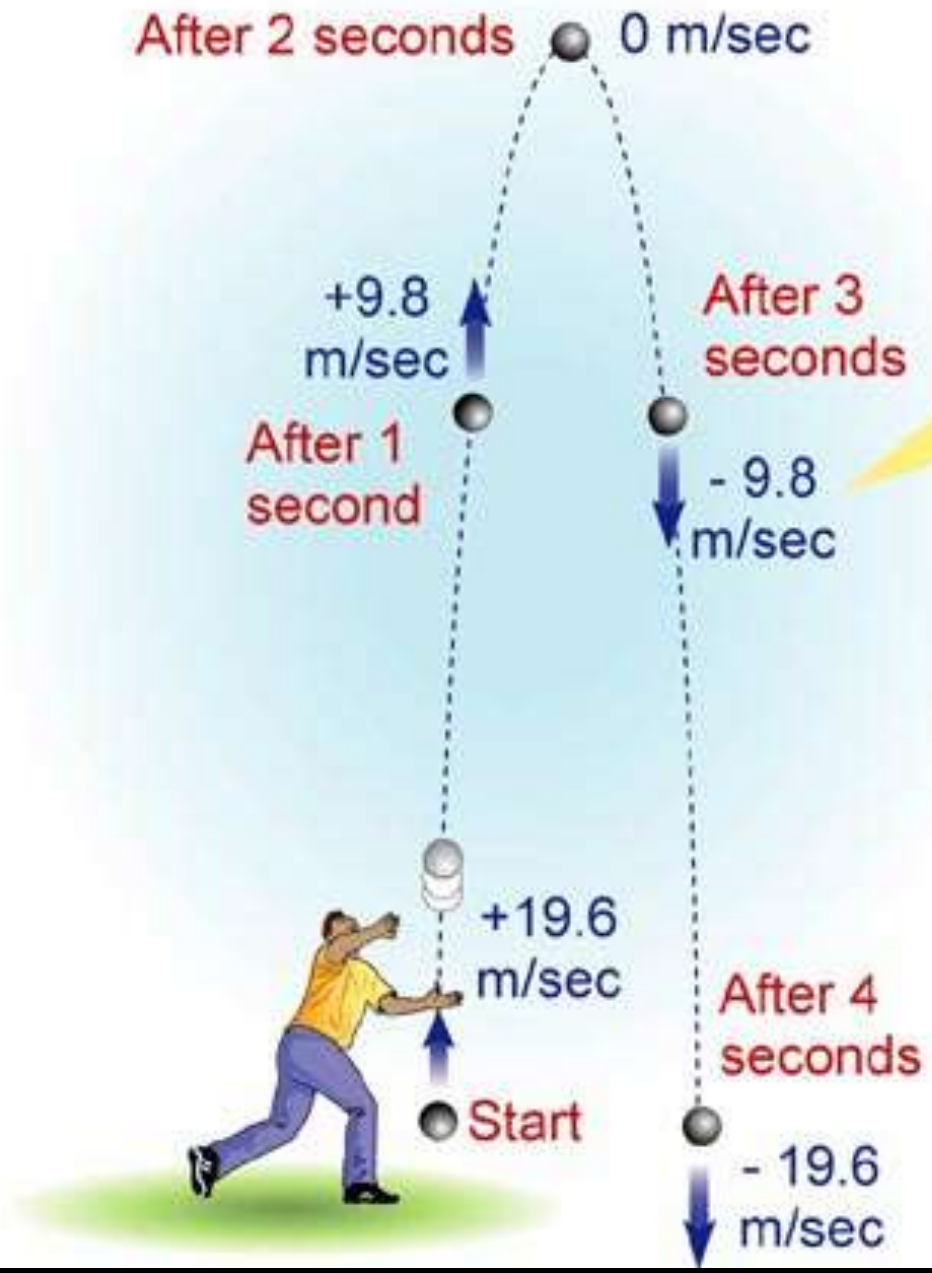
- All objects, when thrown up will continue to move upward for some time, stop momentarily at the peak, and then change direction and begin to fall.



At the top of a path

- If you throw an object up, at the top of the path it has to come to a stop to turn around can come back down.
- Therefore, you can assume a final velocity of zero.

Free Fall with Upward Motion



The speed changes by -9.8 m/sec every second

Time (sec)	Speed (m/sec)	Height (m)
0.0	19.60	0.00
1.0	9.80	14.70
2.0	0.00	19.60
3.0	-9.80	14.70
4.0	-19.60	0.00

- A tennis ball is thrown vertically upward with an initial velocity of 8m/s. What is the ball's speed when it returns to the starting point? How long will it take?
- Knowns?
- Unknowns?

- Stephanie hits a volleyball from a height of .8m and gives it an initial velocity of 7.5m/s straight up. How high will the ball go? How long will it take to get to that height?
- Knowns?
- Unknowns?

4 Kinematic Equations

- All the kinematic equations are related.
- There is always more than one way to solve each problem.
- In general though, one equation is generally easier to use then others.

- Vf = Final Velocity
- Vi = Initial Velocity
- X = distance
- t = time
- a = acceleration
- Acceleration = -9.8 if going up and down

Equations - Kinematic

- $V_f = v_i + at$
- $x = v_i(t) + \frac{1}{2} a(t)^2$
- $x = \frac{1}{2} (V_i + V_f)t$
- $V_f^2 = V_i^2 + 2ax$

- #1. A car accelerates from rest to a speed of 23.7 m/s in 6.5 s. Find the distance the car travels.
- Knowns?
- Unknowns?
- Equation?
- Answer = ?