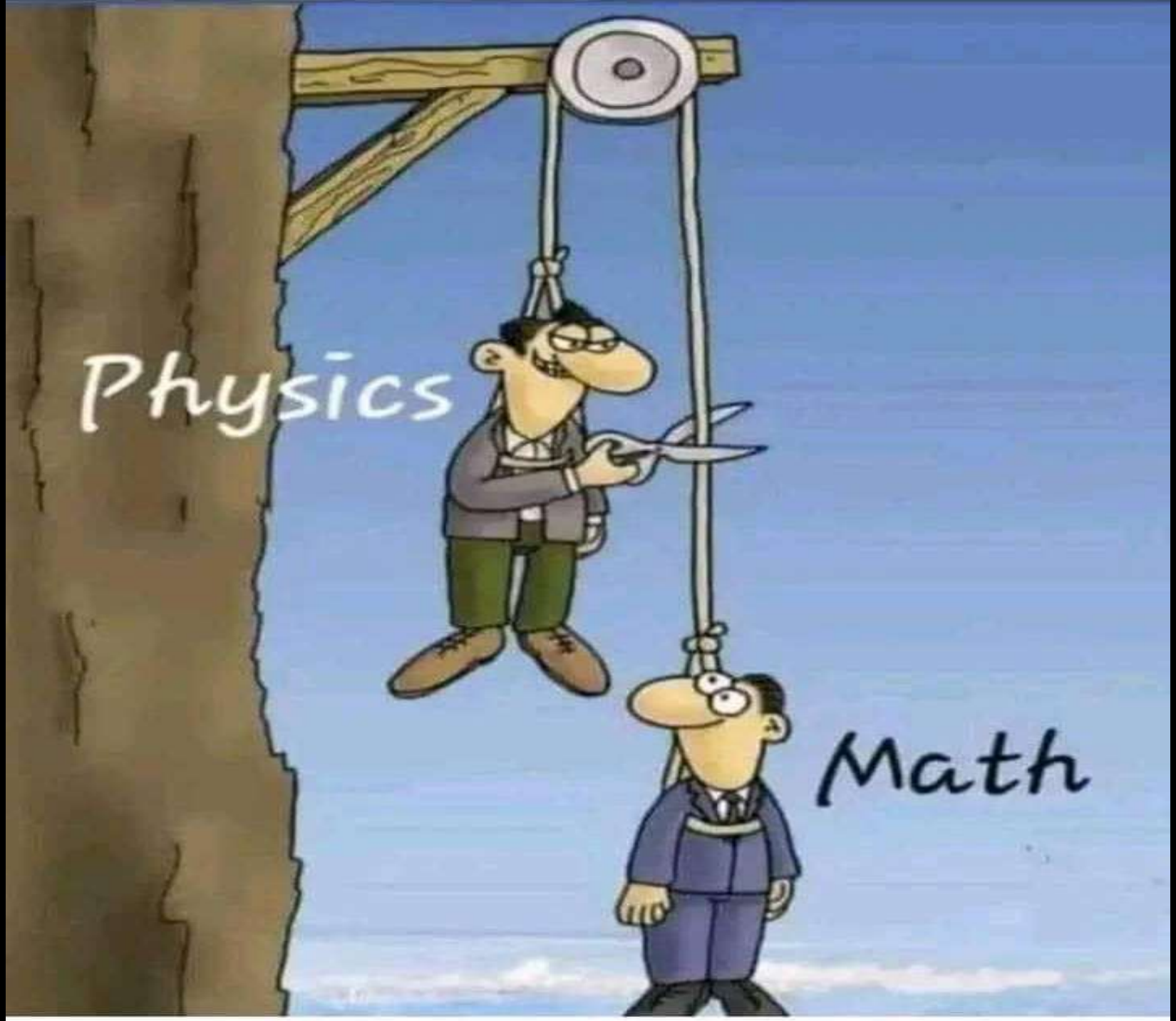

Physics
Math

# *Displacement and Velocity*

Chapter 2-1

Displacement


Direct Measurement
from start to end "short cut"

Distance


Actual Distance traveled

- 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

What term describes a vehicle traveling north on a highway at 65 mph?

- Angular speed
- Linear speed
- Velocity
- Acceleration

What term describes a vehicle traveling north on a highway at 65 mph?

- ○ Angular speed
- ○ Linear speed
- ● Velocity
- ○ Acceleration

A toy car is sent down a 5 m long track in a time of 3.13 seconds. What is the average speed of the car, in m/s?

- 15.65 m/s
- 0.626 m/s
- 1.6 m/s
- 8.13 m/s

A toy car is sent down a 5 m long track in a time of 3.13 seconds. What is the average speed of the car, in m/s?

- ○ 15.65 m/s
- ○ 0.626 m/s
- ◉ 1.6 m/s
- ○ 8.13 m/s

$$S = \frac{d}{t}$$

$$S = \frac{5}{3.13} = 1.597$$

# *Fastest Man-Made Object*

One of the fastest moving man-made objects ever detected was a manhole cover. As a result of the Pascal-B nuclear test in Nevada in 1957, a 900 kg steel plate cap was blown off the top of a test shaft at a speed of more than 66 km/s. The plate was never found, and the experiment's designer, Dr Brownlee, believes that although the plate may have exceeded Earth's escape velocity, it is likely to have been vaporized by compression heating in the atmosphere. The calculated velocity is an estimate as the high-speed camera footage of the incident captured the cap in just one frame

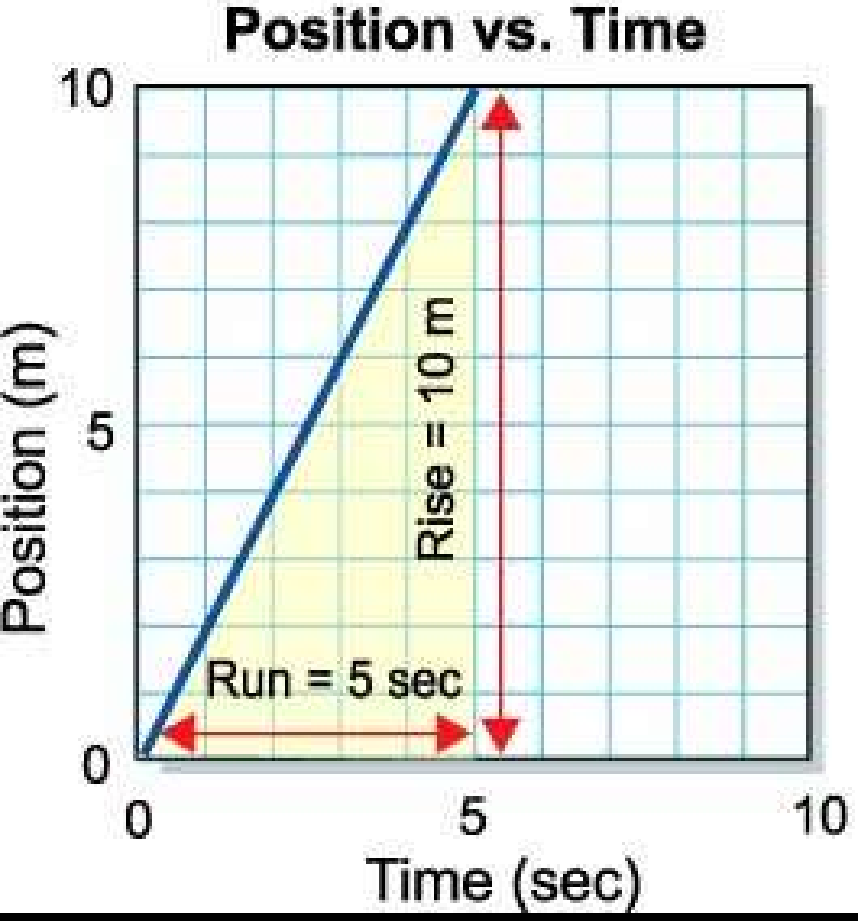
# *Graphs*

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

- 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.

$$\text{Slope} = \frac{\text{rise}}{\text{run}} = \frac{\text{distance}}{\text{time}} = \text{speed}$$

# Position vs. Time Graph



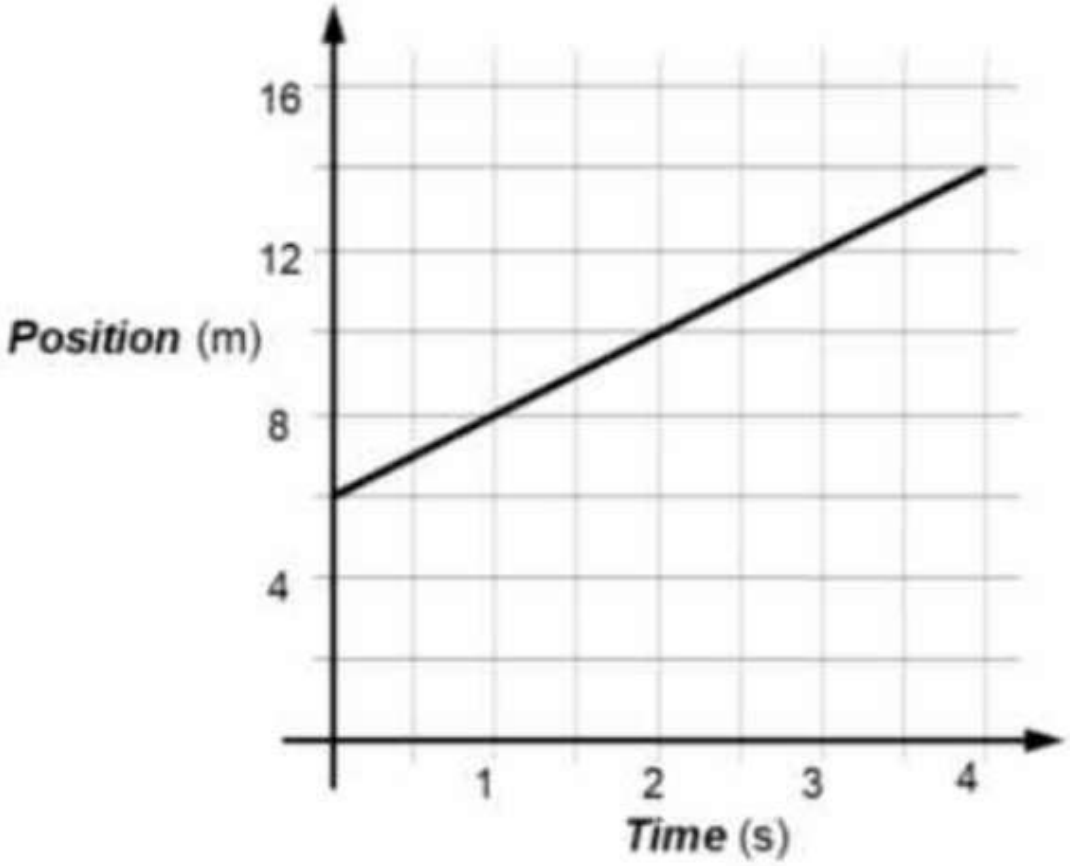

$$\text{Slope} = \frac{\text{rise}}{\text{run}}$$

$$= \frac{10\text{ m}}{5\text{ sec}}$$

**= 2 m/sec**

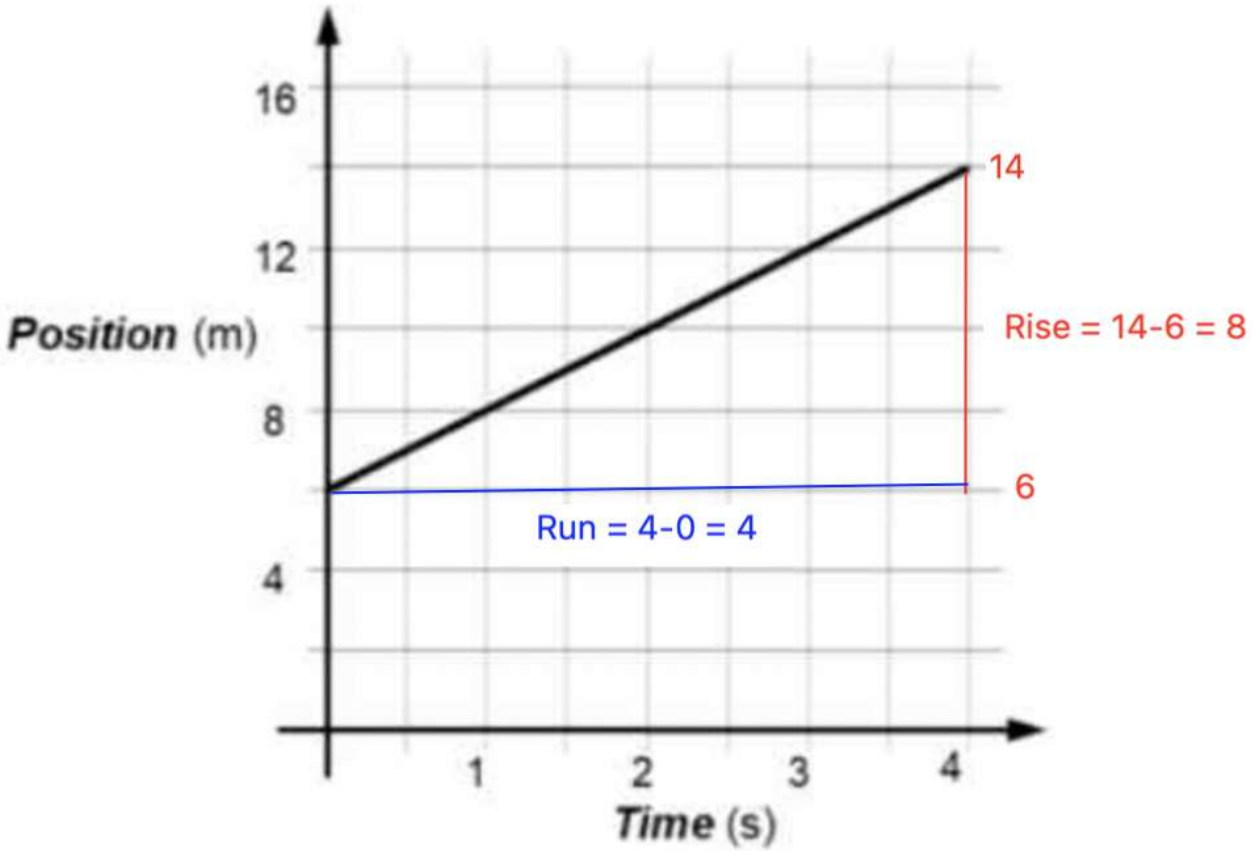
The slope of position vs. time is the **speed.**

What is the average velocity represented on the graph?



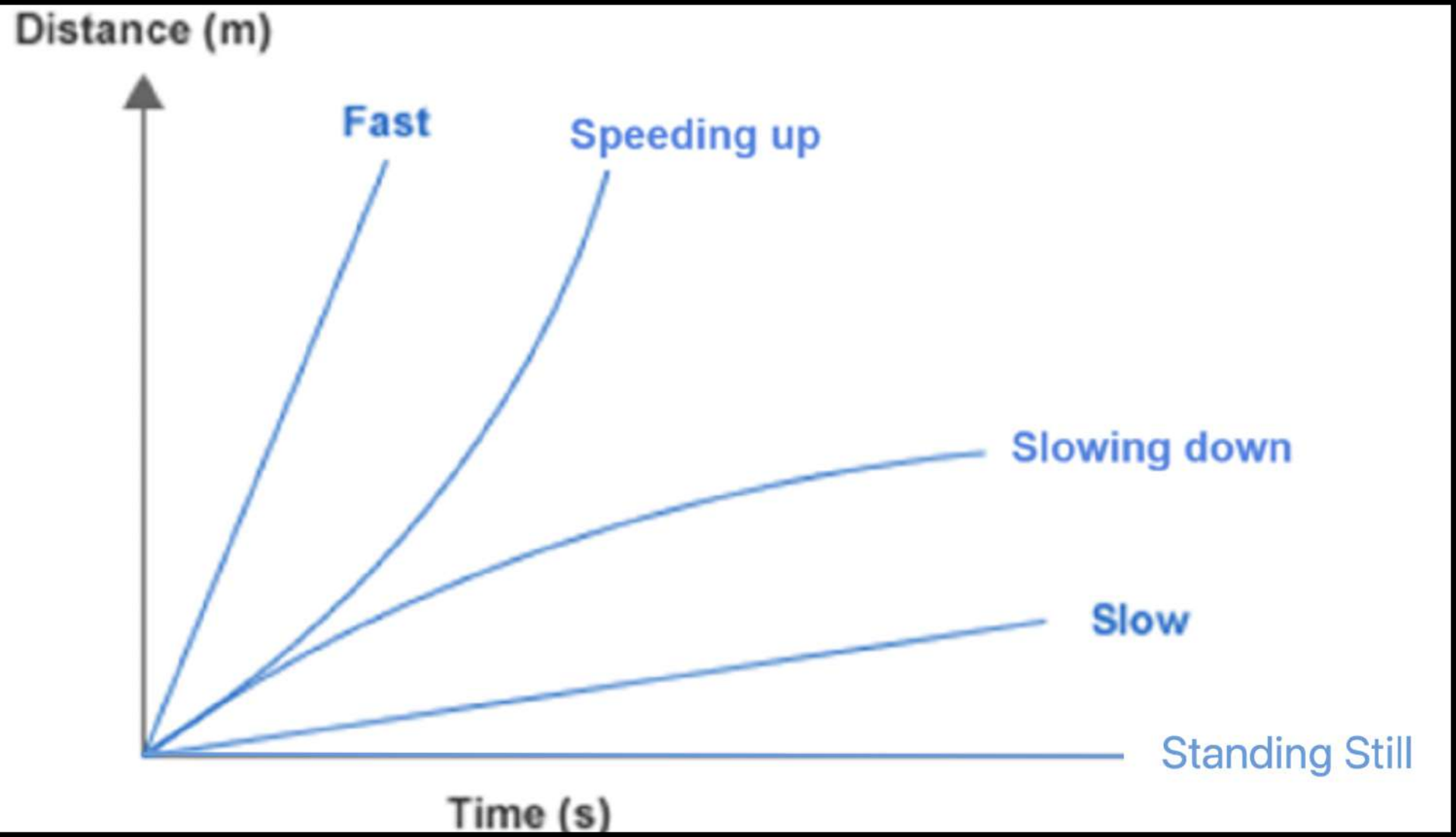

- ○ 1.5 m/s
- ○ 4 m/s
- ○ 2 m/s
- ○ 3.5 m/s

What is the average velocity represented on the graph?

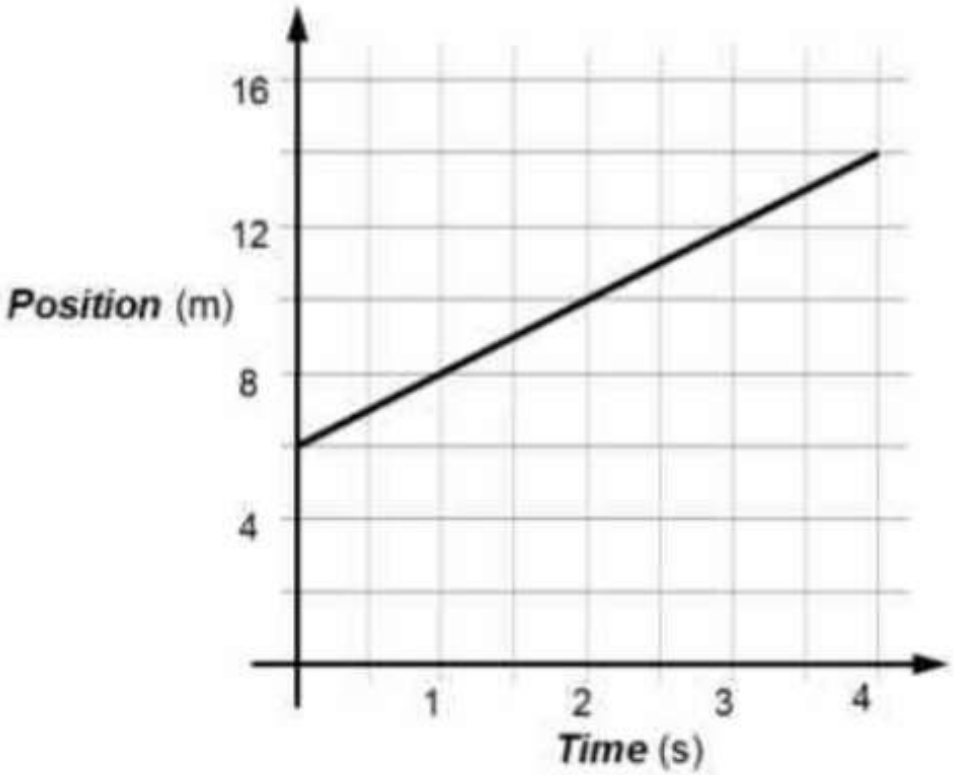



Rise/Run = Distance/time = 8/4 = 2

- 1.5 m/s
- 4 m/s
- 2 m/s
- 3.5 m/s

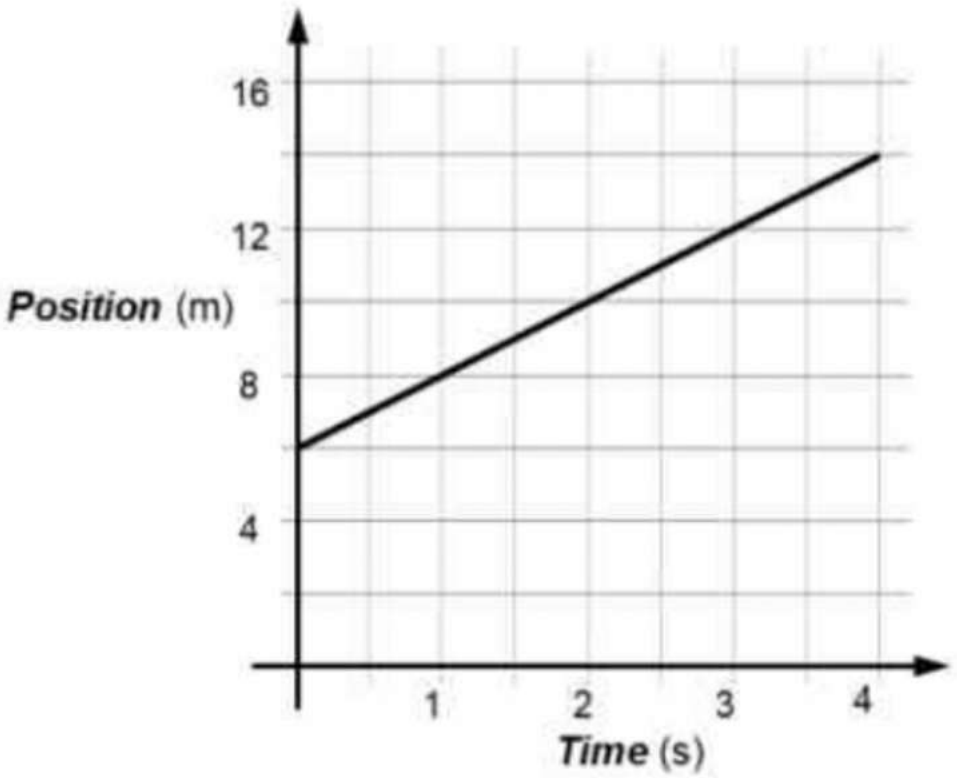

Distance (m)
Fast
Speeding up
Slowing down
Slow
Standing Still
Time (s)

What type of motion is represented on the graph?




- ○ Standing still
- ○ Constant speed
- ○ Speeding up
- ○ Slowing down

What type of motion is represented on the graph?

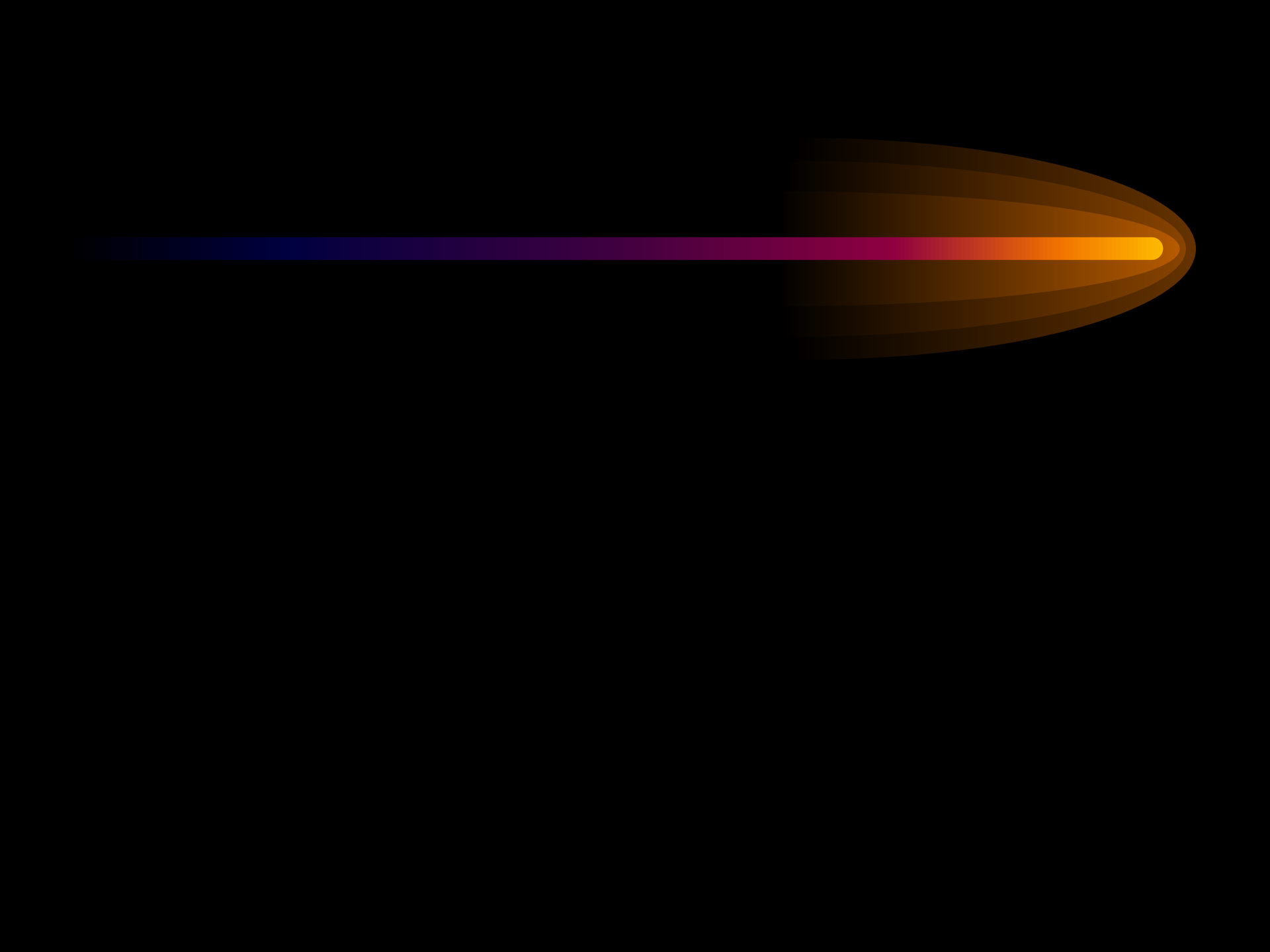



- ○ Standing still
- ● Constant speed
- ○ Speeding up
- ○ Slowing down

*If you get a speeding ticket, is it because your instantaneous speed was too fast, or your average speed was too fast?*

*Usually, it's because your instantaneous speed was too fast.*

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



*But on a toll road, you can get a ticket if your average speed exceeds the legal limit!*


# *Chapter 2-2*

# Acceleration

# *Variables*

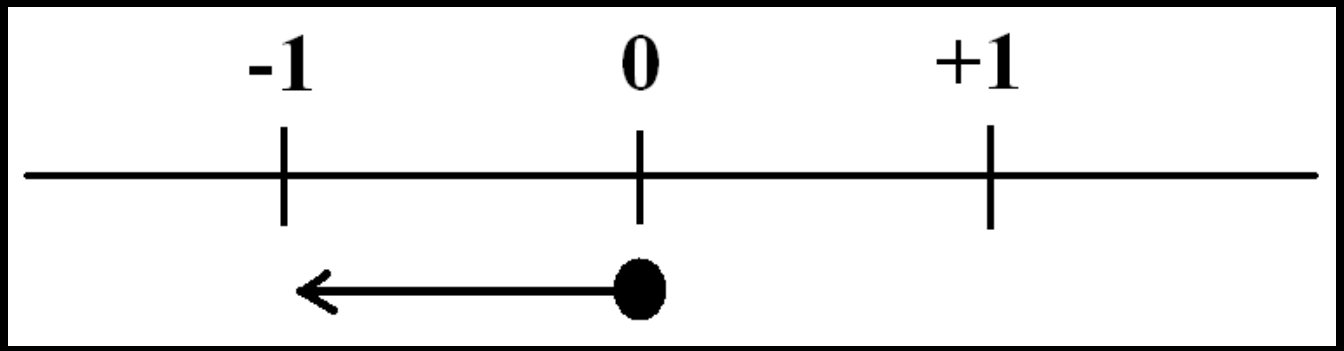
- a = acceleration ($m/s^2$)
- Vf = Final Velocity (m/s)
- Vi = Initial Velocity (m/s)
- t = time (s)
- X = distance (m)
- Y = height (m)
- g = gravity = -9.8 $m/s^2$

- Acceleration is the measure of how fast something speeds up or slows down.
- $a = (v_f - v_i)/t$
- a = acceleration
- vf = final velocity
- vi = initial velocity

- Si Units for Acceleration is $m/s^2$
- Velocity units are m/s
- Time = seconds
- Time can NEVER be negative

# *Accelerating Versus Decelerating*

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



# 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: $5.97 \times 10^{24}$ m  Mass of moon: $7.34 \times 10^{22}$ kg  Distance between centers of Earth and moon: $3.84 \times 10^{8}$ 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 ($6.38 \times 10^{6}$ m from its center). **Answer:** 489 N

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

Practice your problem-solving skills

$A \equiv (Vf - Vi) / t$

A robot changes velocity from 2 m/s to 7 m/s in a 3 second period. What is the acceleration?

A robot changes velocity from 2 meters per second to 7 meters per second in a 3 second period. What is the acceleration?

- 5.0 m/s
- 5.0 $m/s^2$
- 1.6 m/s
- 1.6 $m/s^2$

$$a = \frac{v_f - v_i}{t}$$

$$a = \frac{7 - 2}{3} = \frac{5}{3} = 1.\overline{66}\ \frac{m}{s^2}$$

# *Chapter 2-3*

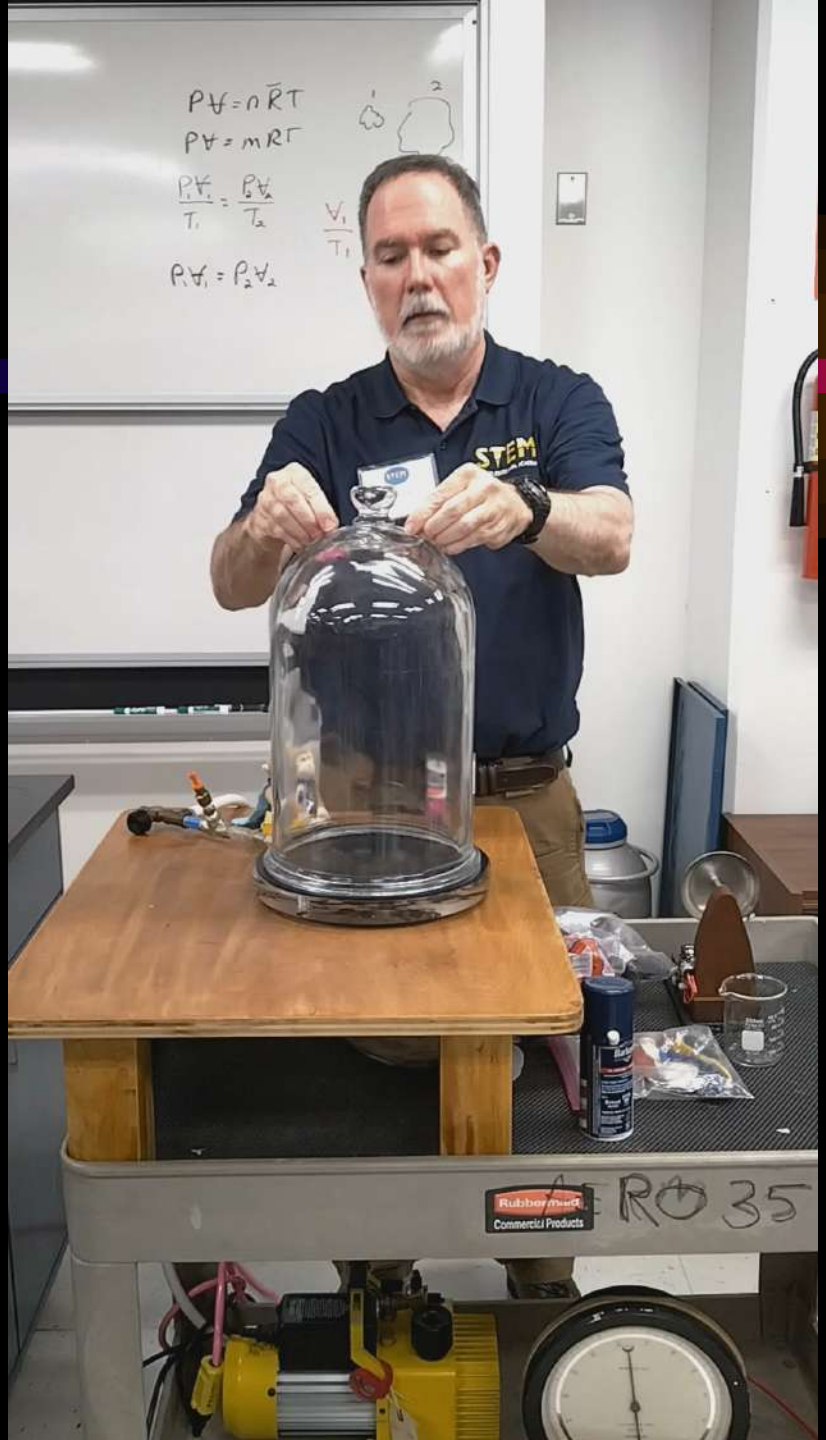
## Falling Objects

- 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 **$9.8 m/s^2$**.

Gravity

1. Sheet of paper dropped same time as roll of tape?
2. Same sheet of paper in crumbled ball dropped same time as roll of tape?

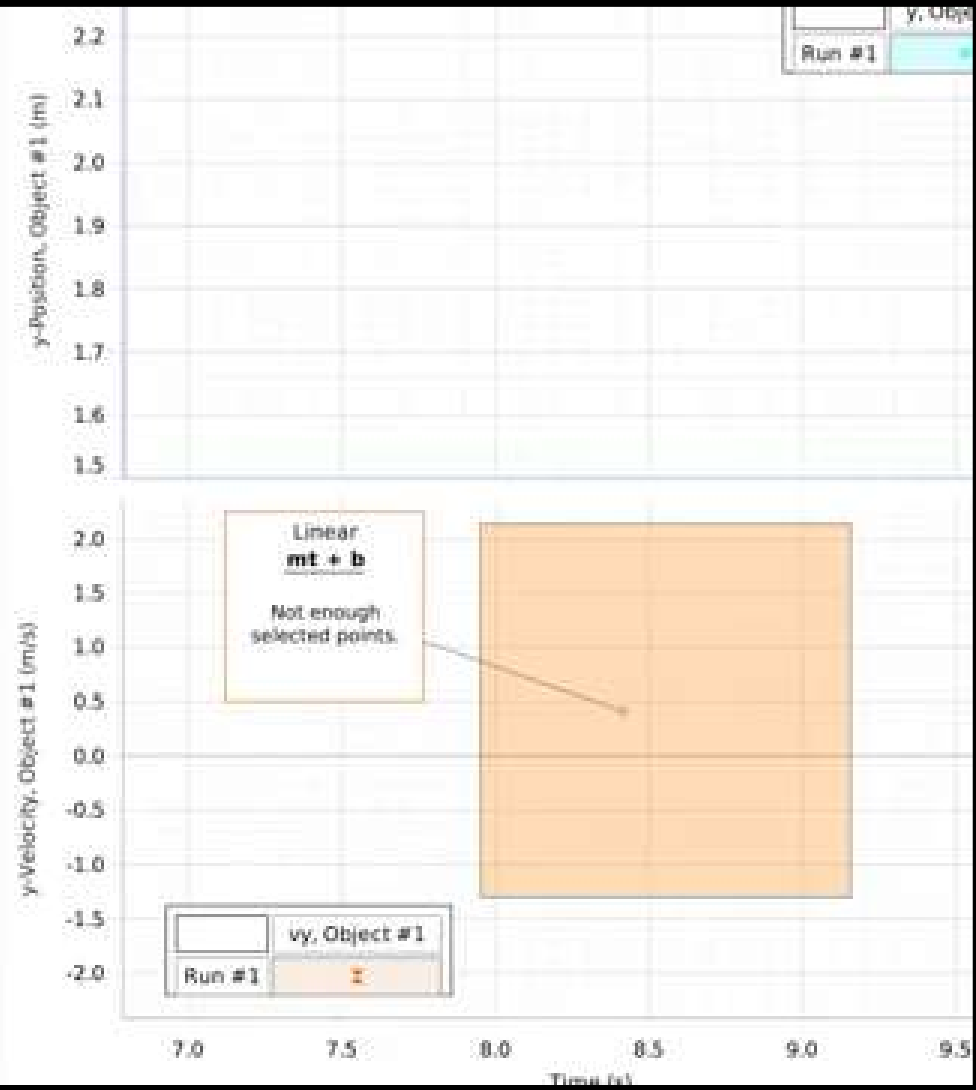

BBC TWO
CAP MAZZELLA 16TON

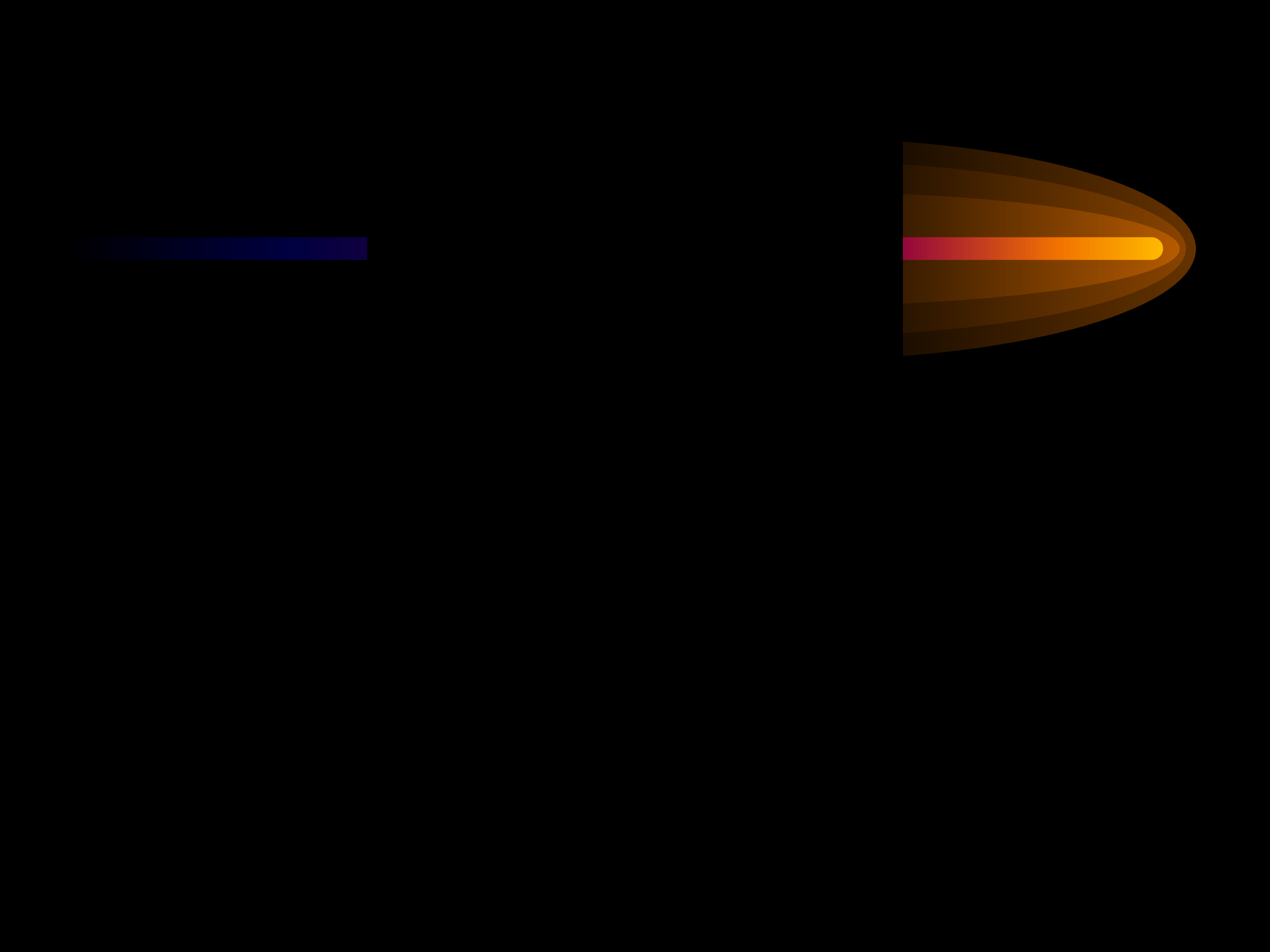

$P\forall = n\bar{R}T$
$P\forall = mRT$
$\frac{P_1\forall_1}{T_1} = \frac{P_2\forall_2}{T_2}$
$P_1\forall_1 = P_2\forall_2$
$\frac{V_1}{T_1}$
1
2
STEM
Rubbermaid
Commercial Products
AERO 35

- 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.

# *Gravity on the Moon*

Gravity on the moon is roughly 4.9 $m/s^2$ compared to Earth at 9.8 $m/s^2$.

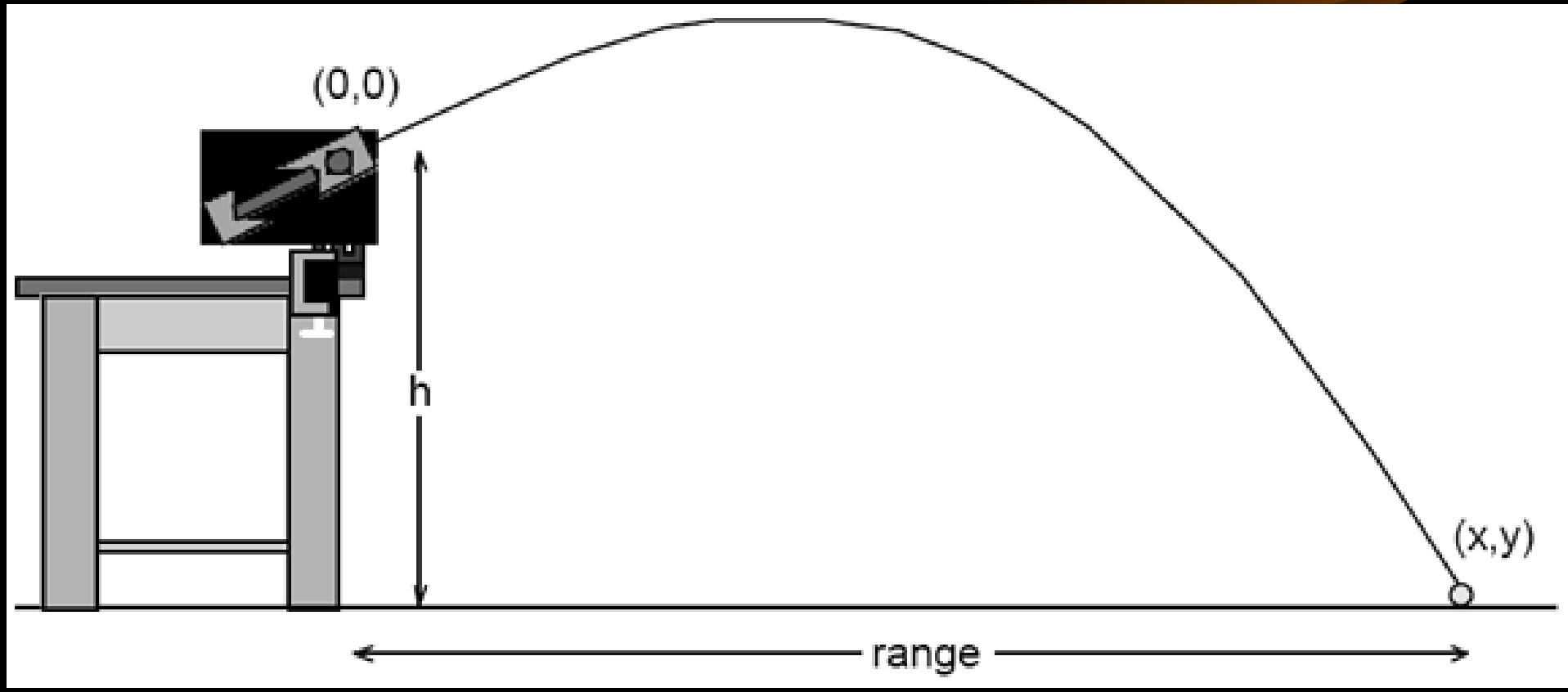

Run #1
y-Position, Object #1 (m)
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
Linear
mt + b
Not enough selected points.
y-Velocity, Object #1 (m/s)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
vy, Object #1
Run #1
7.0
7.5
8.0
8.5
9.0
9.5

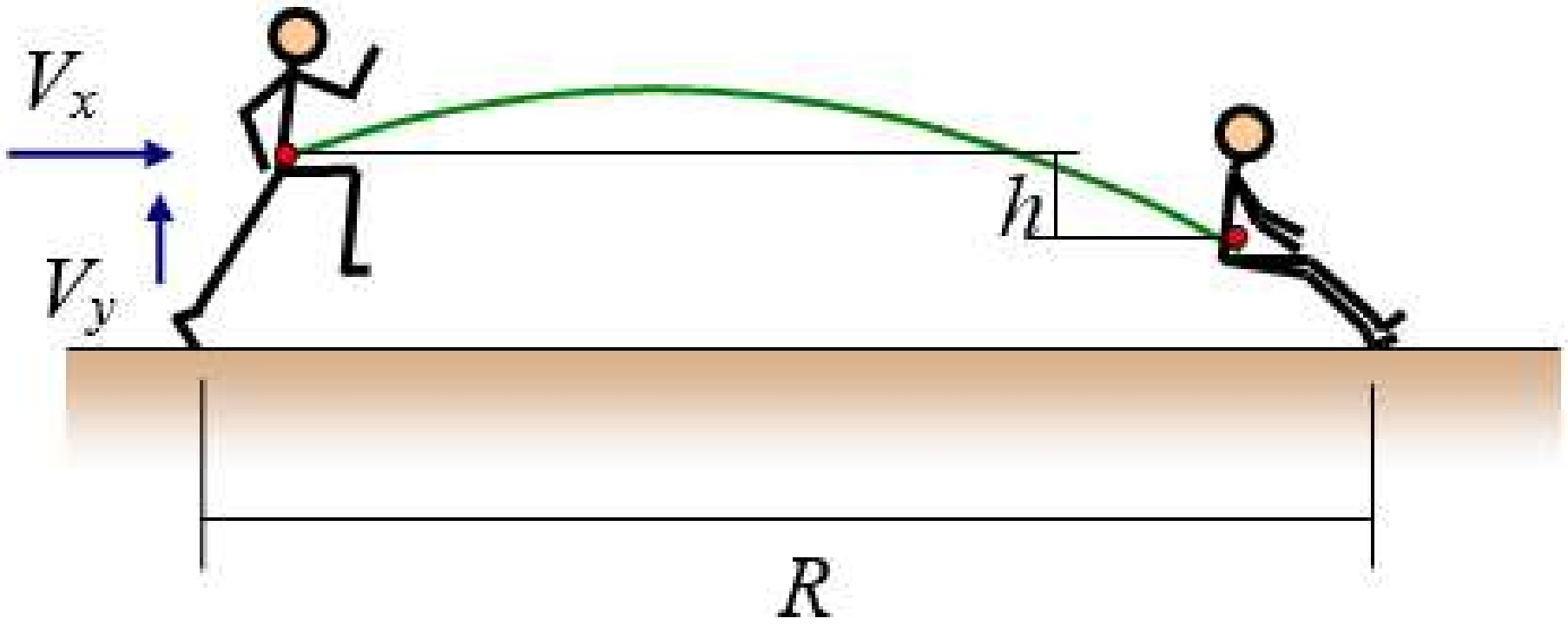


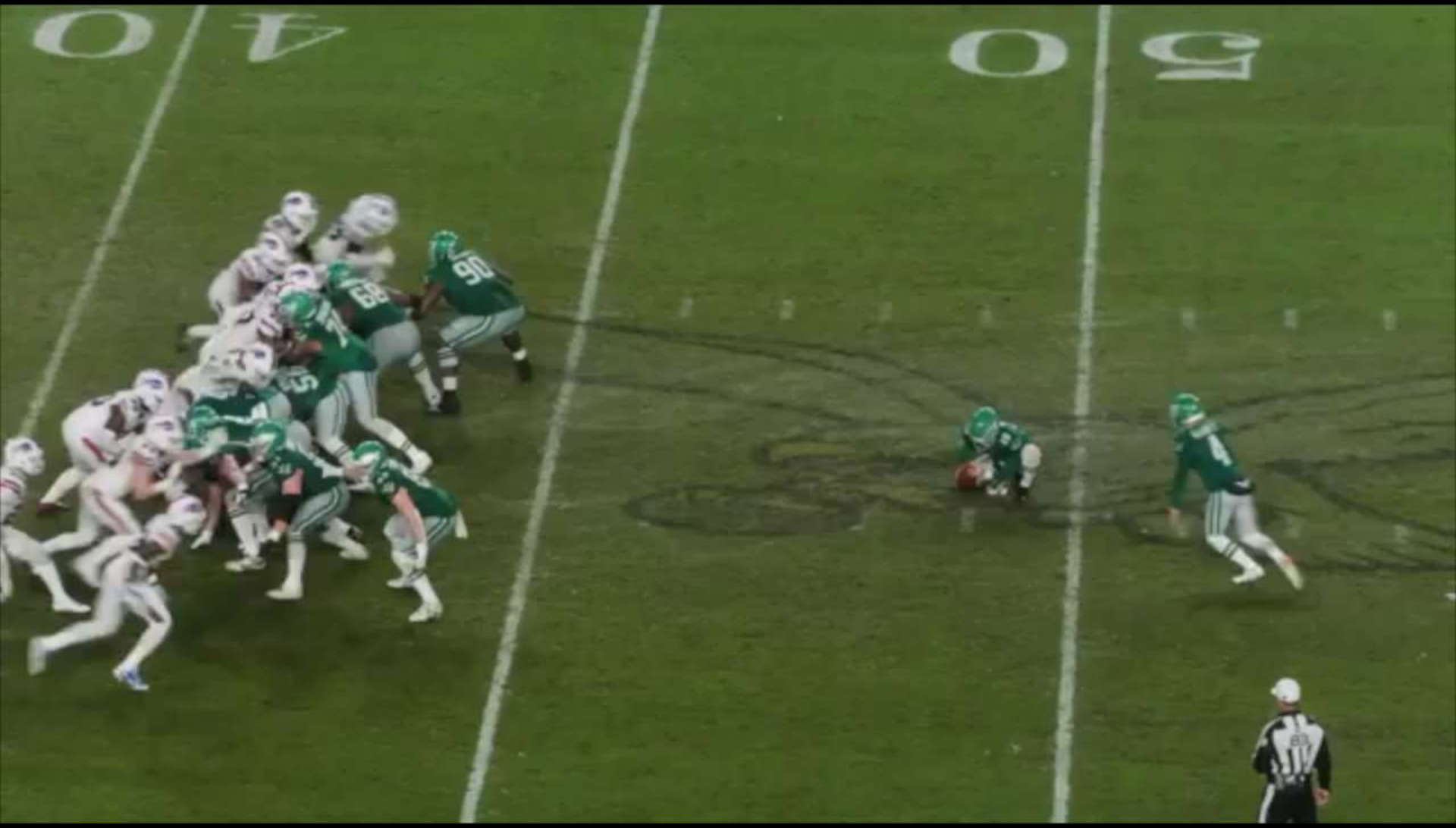
# Projectile Motion

- Objects that are thrown or launched into the air and are subject to gravity are called projectiles.
- The path of a projectile is a curve called a **parabola**.
- The velocity of the projectiles for sample problems will be considered constant -no air resistance

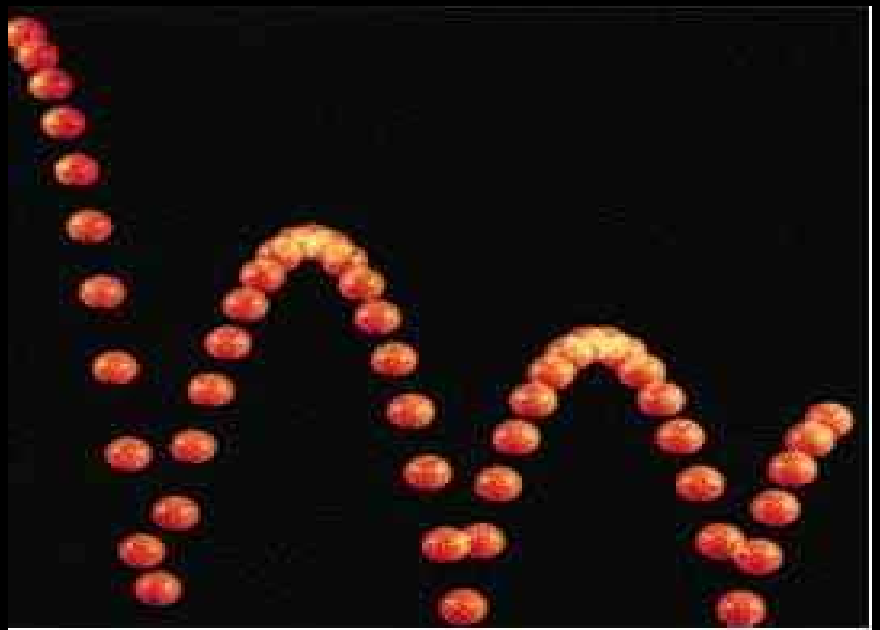

swissphoto
Surveying & Mapping


(0,0)
h
(x,y)
range


$V_x$
$V_y$
$h$
$R$


40
50

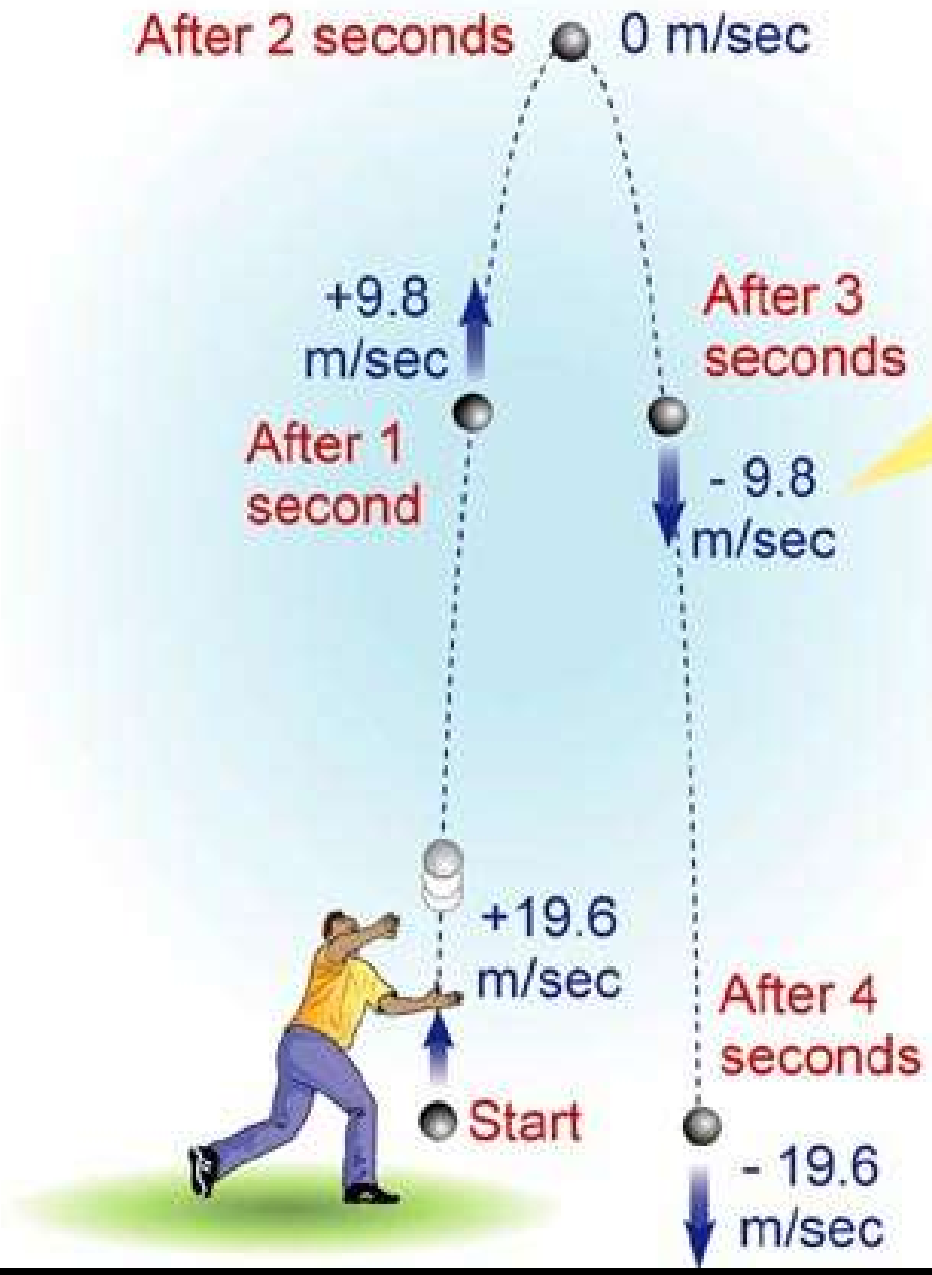
- All objects, when thrown up will continue to move upward for some time, stop momentarily at the peak, and then change direction and begin to fall.



# *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 at the top of the path. (It “Deacelerates”)

# 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 |

# Equations

- $S = d/t$
- $y = -.5g(t^2)$
- $V_f = V_i + (a)t$