AN ECLIPSE PROBLEM TO ILLUSTRATE SPEED VS. VELOCITY

- Totality begins in Lincoln City, OR and ends in Charleston, SC 4.5 hours later. If you were to drive, the ***total distance*** of this path is 4.8×10^3 km. How fast would you need to drive to follow the totality across the US in m/s?
- The ***displacement*** from Lincoln City to Charleston is 4.0×10^3 km. How fast would you need to fly to follow the totality across the US in m/s?

THINGS I NOTICED FROM QUIZ 1

- Miles per hour (mph), etc – the ”per” indicates division.
  - $\frac{m}{s}, \frac{mi}{hr}, \frac{km}{hr}$
- Many people tried to do $-\frac{9.8\frac{m}{s^2}}{4.0s}$
  - This is $-9.8\frac{m}{s^2} * \frac{1}{4s}$

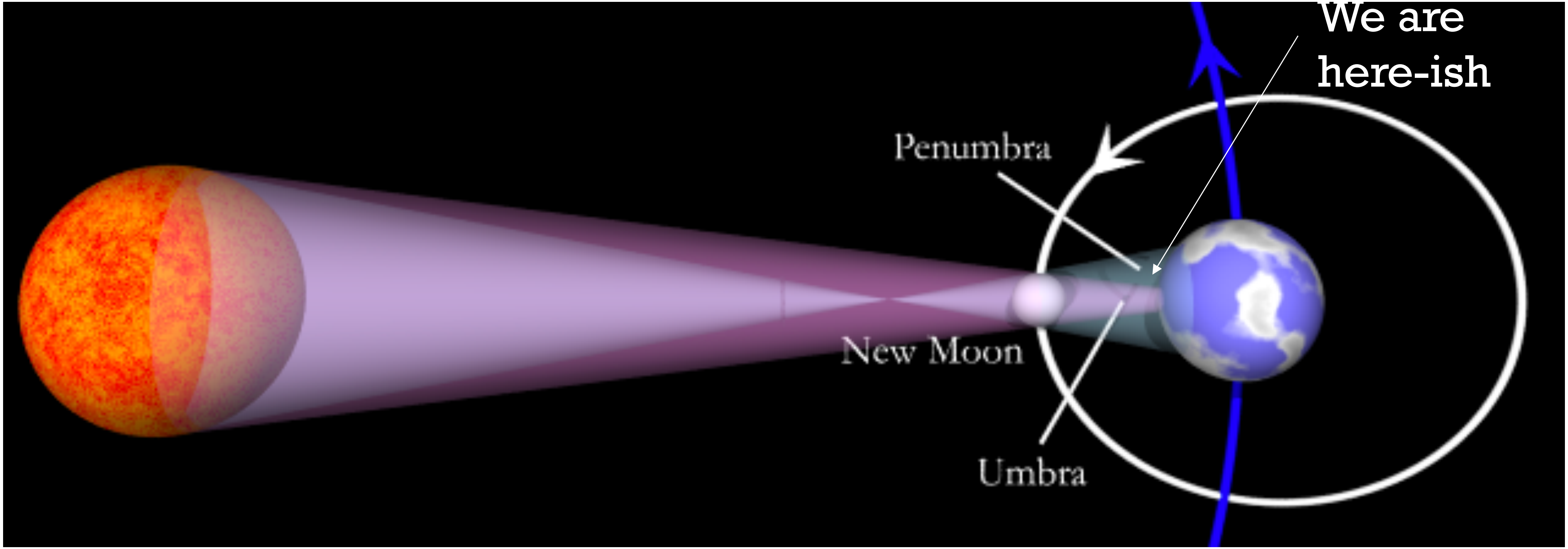
QUIZ 1

- If you would like to retake the quiz, I will offer another quiz lunch and after school tomorrow and Weds
  - I will keep the better score

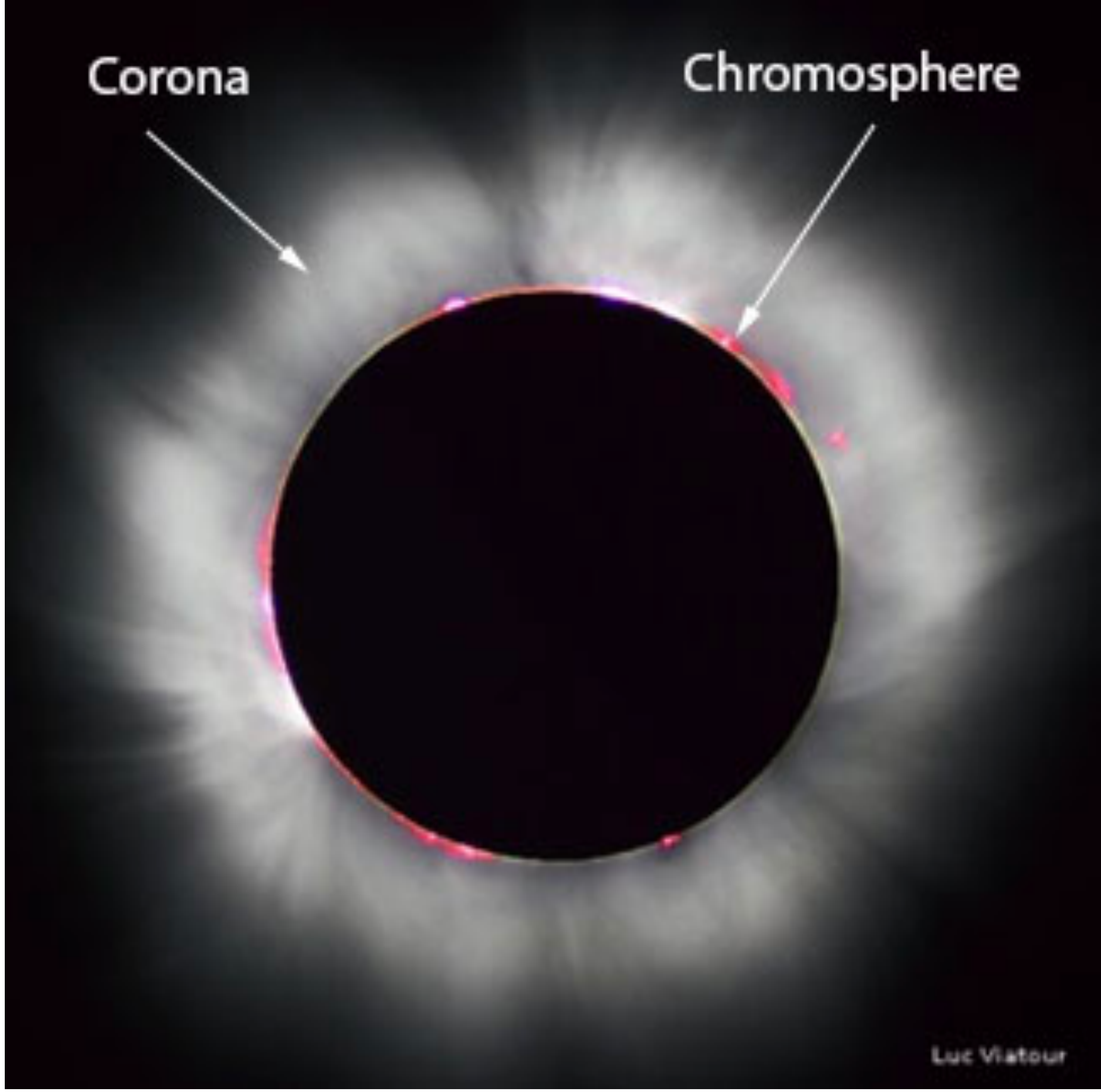
GOALS FOR TODAY

- The eclipse!
- Free fall
- Strategies for solving kinematic equations

THE ECLIPSE!



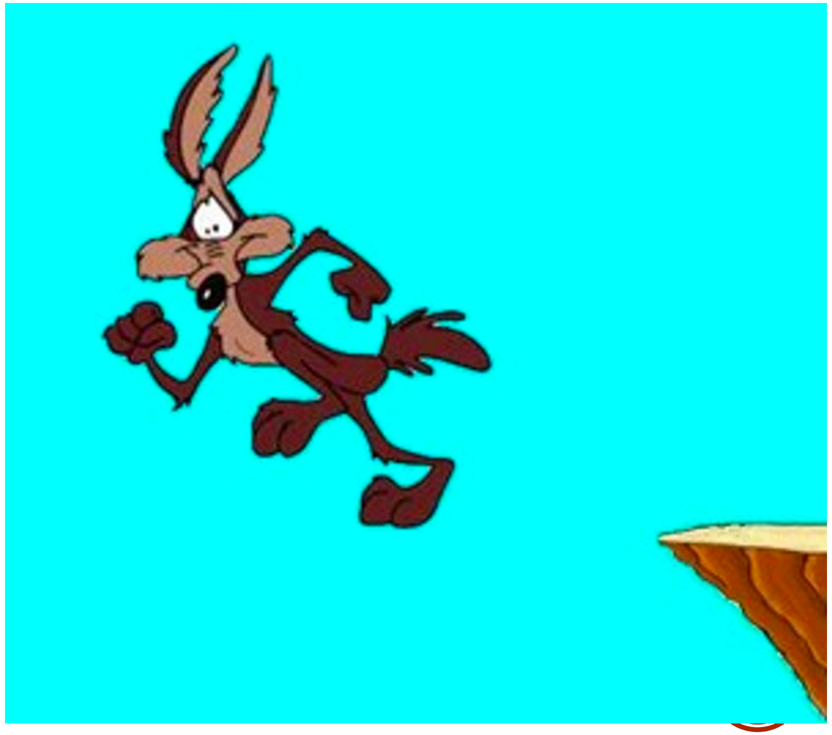
- The **corona** is the outer atmosphere of the sun
- The **chromosphere** is the thin layer of the sun's atmosphere just above the photosphere



OK BACK TO STUFF YOU NEED TO KNOW

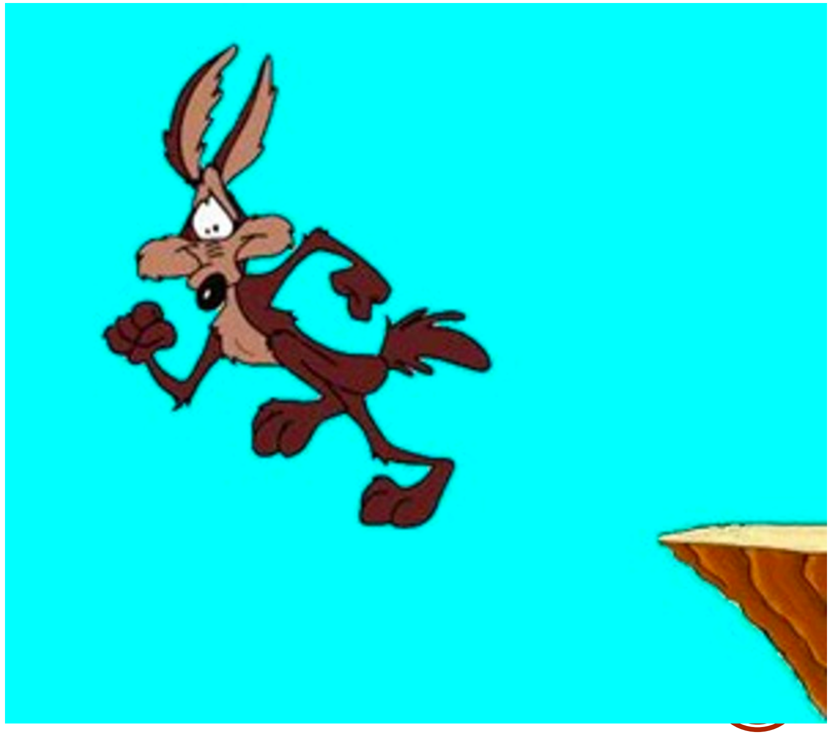
FREEFALL

- All objects accelerate toward the Earth under the unforgivable force of gravity
- They pick up speed as they descend



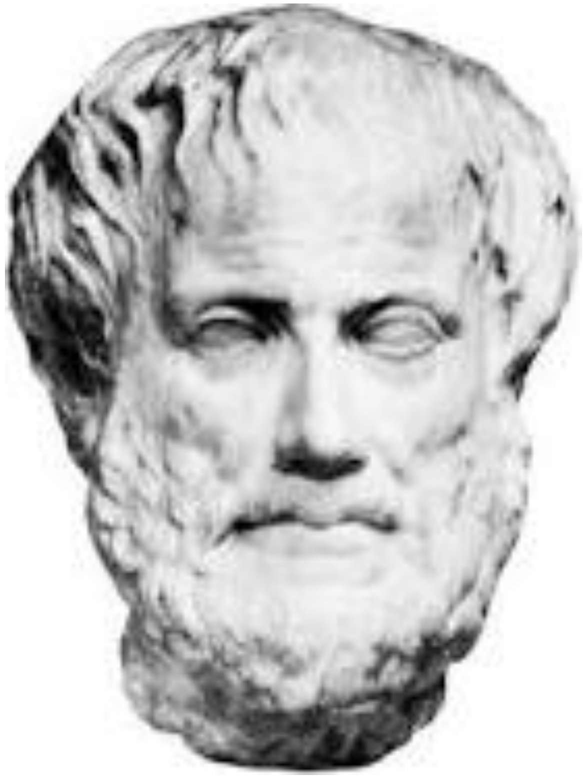
FREEFALL

- They pick up speed as they descend.
- If acceleration due to gravity is -9.8m/s^2, by how much does the speed increase every second?
  - *9.8 m/s*



FREEFALL – THE HISTORY

- Up through the 16th century, people believed the teachings of Aristotle…
  - “A body which is ten times as heavy as another will move ten times as rapidly as the other.”



FREEFALL – THE HISTORY

- Then Galileo showed up, dropped some masses off the Leaning Tower of Pisa, and came to an interesting conclusion…

- **Acceleration due to gravity affects all objects the same regardless of their mass!**
  - If you dropped an elephant and a mouse off the Tower of Pisa, they would gracefully land at the same time.
- Any observed differences are due to **air resistance**.

- The faster an object goes, the larger **slowing effect** air resistance has on slowing the object.
- **Object shape/area** also plays a role
- Without air resistance, things would fall faster and faster without anything to slow them!

AIR RESISTANCE

- **Terminal velocity** happens when the force of air resistance (drag force) = Force due to gravity –> maximum possible speed
- (Side note: terminal velocity for a baseball is 95 mph)

AIR RESISTANCE

COMMON MISCONCEPTIONS

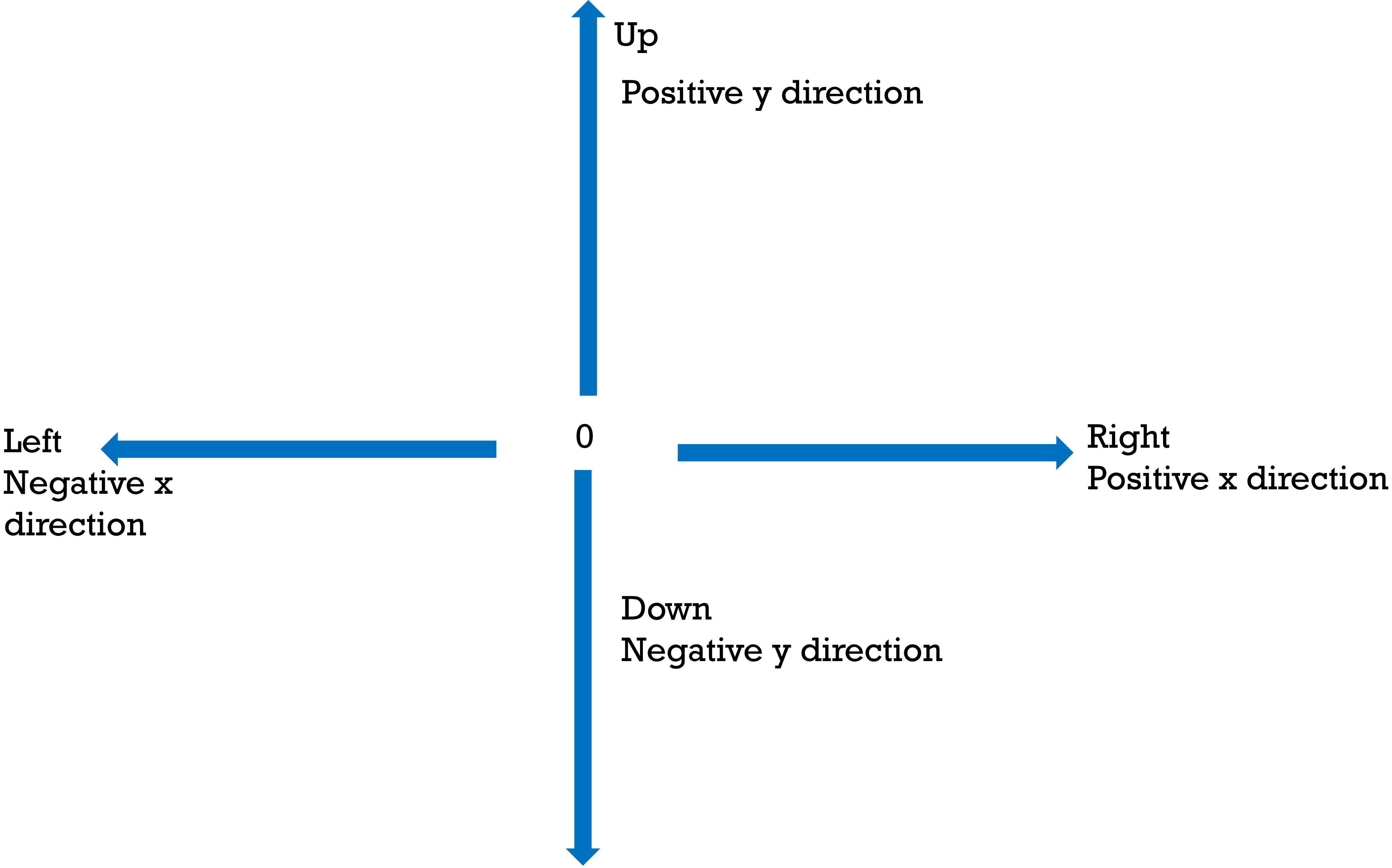
- "Velocity and acceleration will always be pointing in the same direction."
  - **If you throw a ball up**, velocity is pointing upward but acceleration (gravity) is pointing downward
  - **A braking car** has a velocity going one direction but the acceleration is opposing the velocity, causing it to slow down.

COMMON MISCONCEPTIONS

- "An object has zero acceleration at its highest point."
  - An object's *velocity* is 0 at its highest point

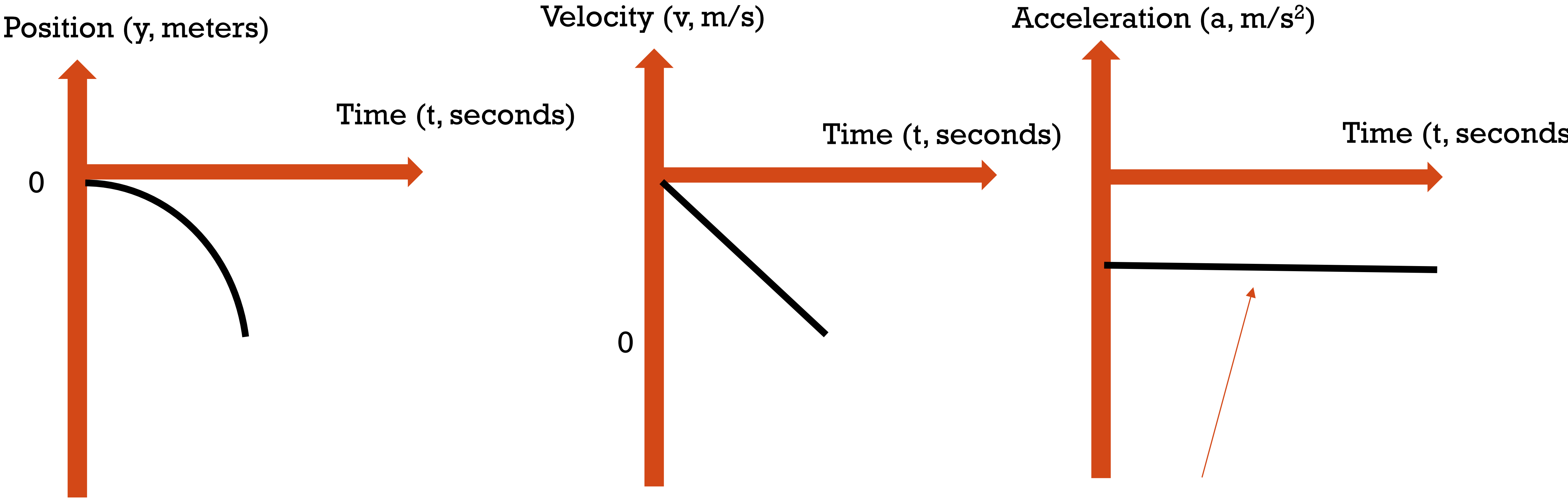
COMMON MISCONCEPTIONS

- "An object's acceleration is increasing as it falls."
  - Acceleration of an object in free fall is always -9.81 m/s^2. It's the *speed* that is increasing as it falls.



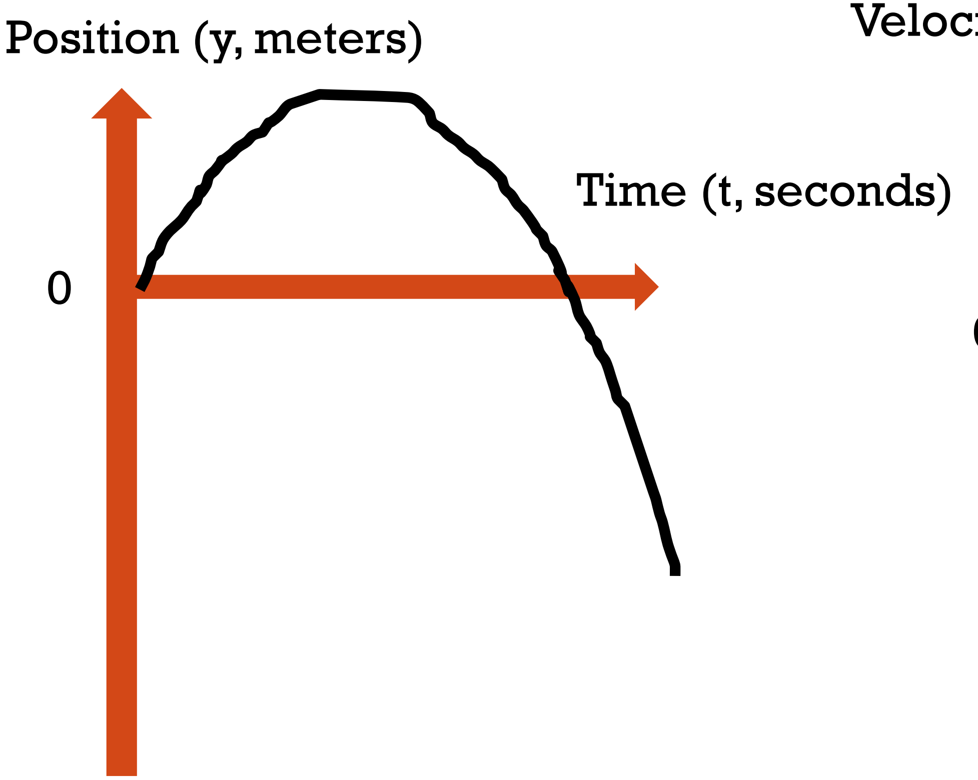
Up
Positive y direction
Left
Negative x direction
0
Right
Positive x direction
Down
Negative y direction

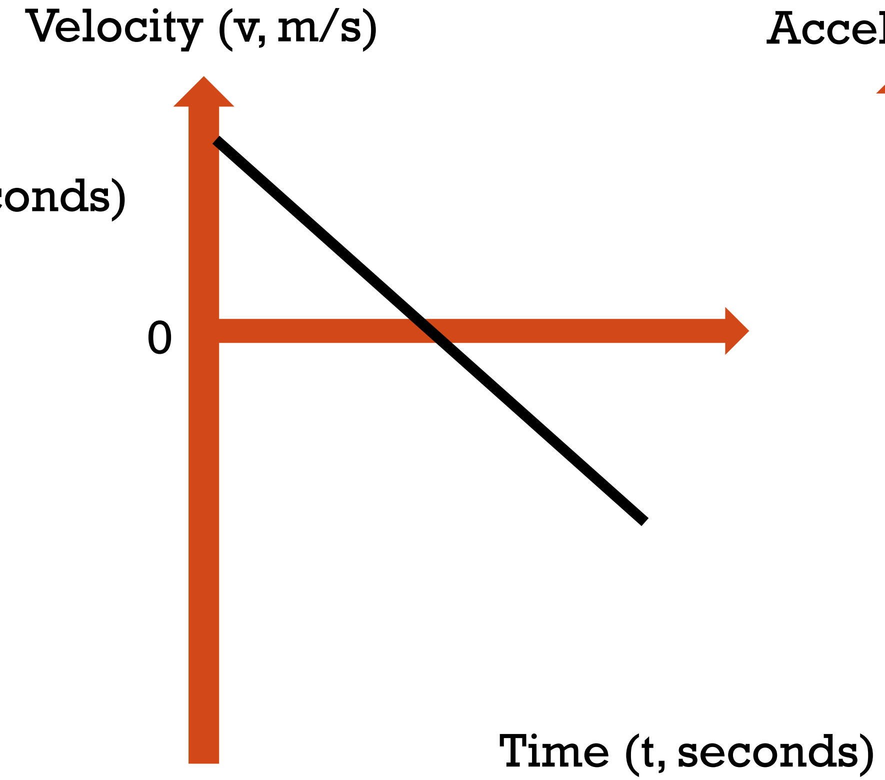
GRAPHING FREE FALL IF WE JUST DROP THE THING

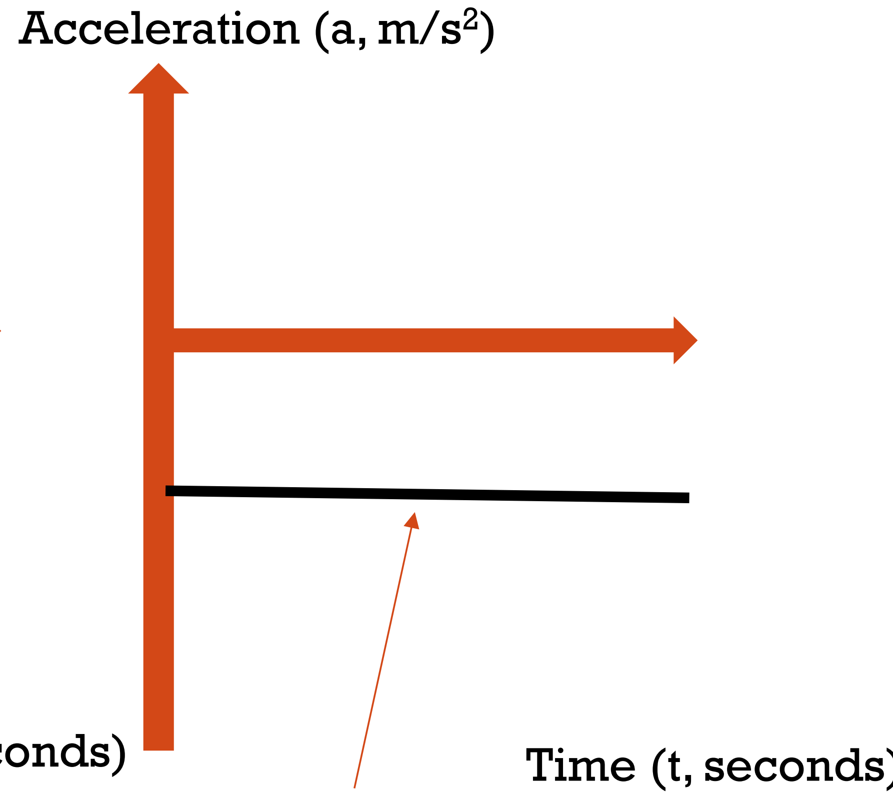


What is the value of this acceleration?

GRAPHING FREE FALL IF WE THROW THE THING UP

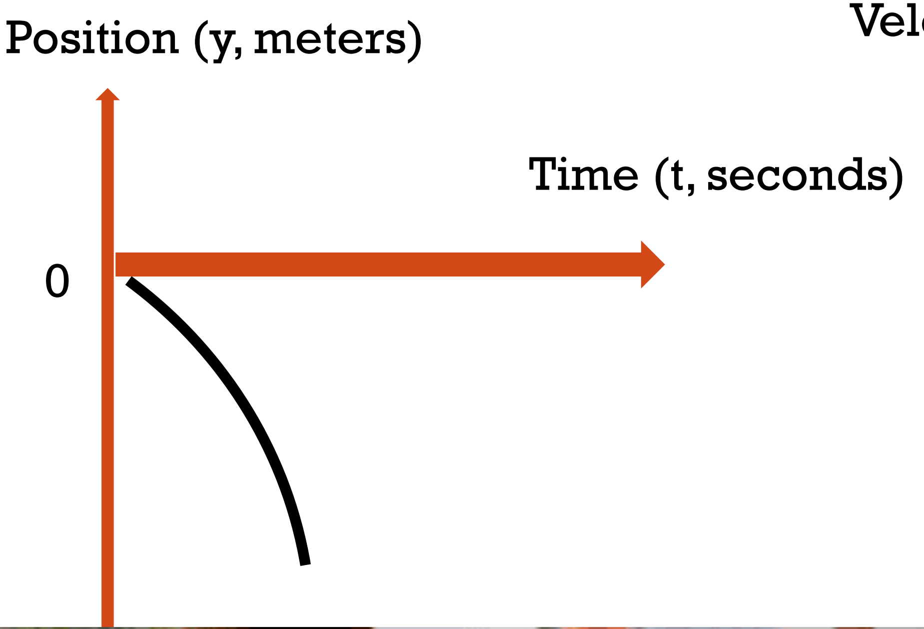


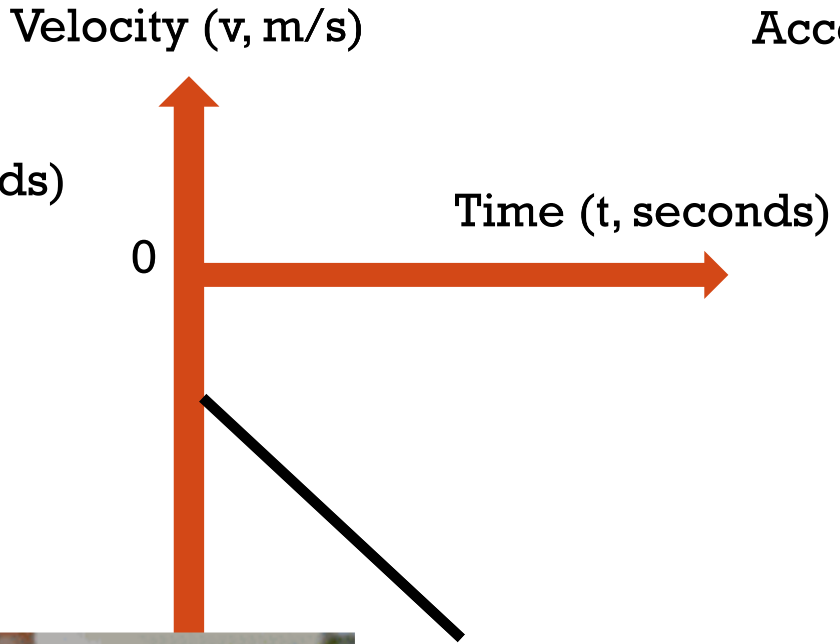


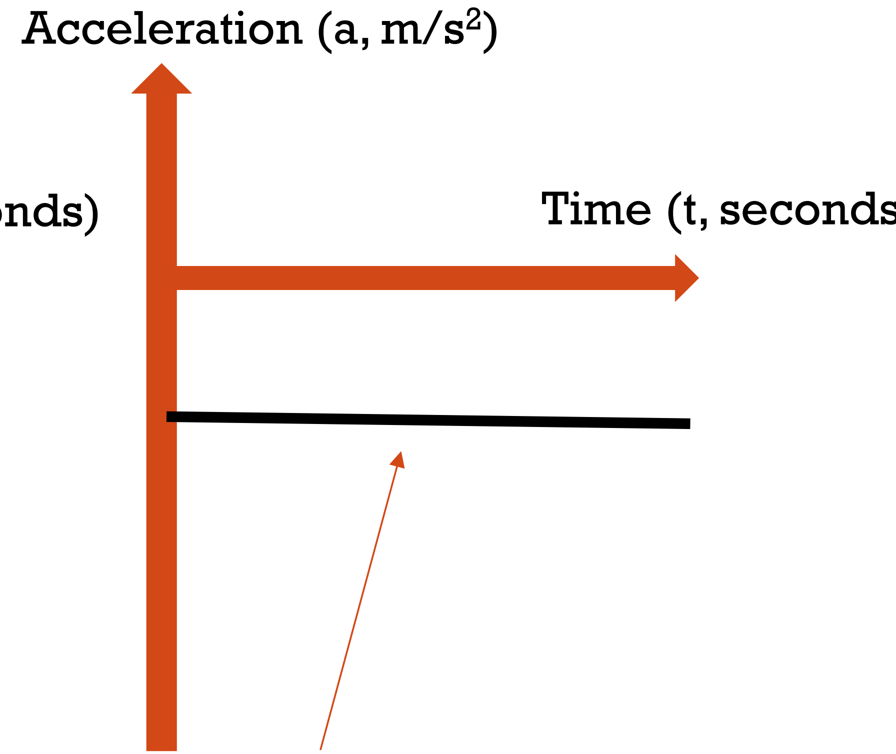


What is the value of
this acceleration?

GRAPHING FREE FALL IF WE THROW THE THING DOWN







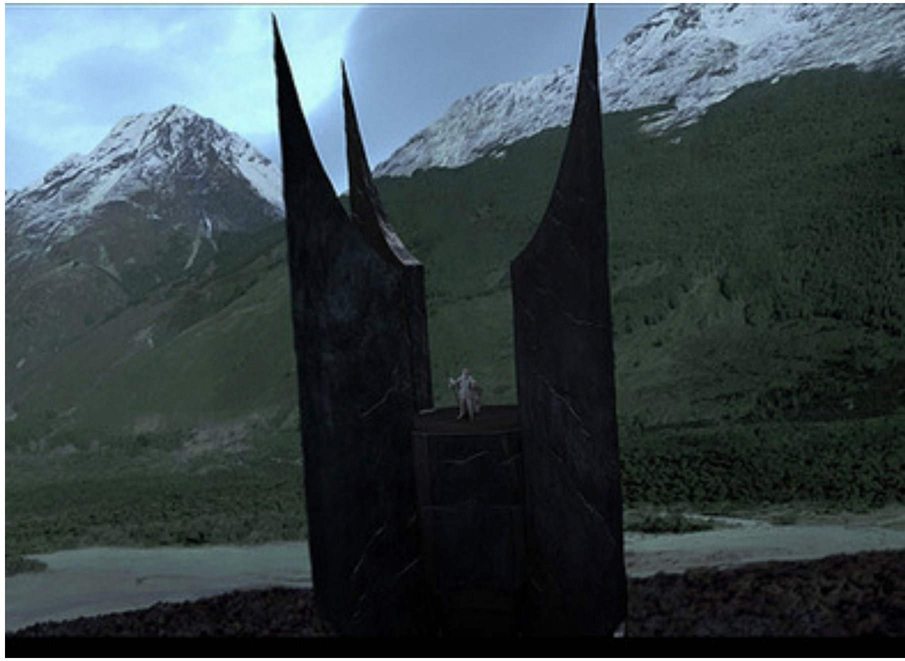
What is the value of this acceleration?

CALCULATIONS WITH FREEFALL

- Kinematic equations stay the same, but now *g* replaces *a*, where *g* = -9.81m/s², remember it is negative because *g* points down.
- $x_f = x_i + v_i t + \frac{1}{2}at^2$ ➡ $x_f = x_i + v_i t + \frac{1}{2}(-\frac{9.8m}{s^2})t^2$

- Saruman is conducting physics experiments from atop the Tower of Orthanc.
- If he drops his seeing stone (a ball) from the peak of his fortress, how far will the ball have fallen after 1.00 s, 2.00 s, and 3.00 s? (Neglect air resistance)
  - 4.90 m, 19.6 m, 44.1 m
- Plot these on a position vs. time graph
- Now graph the velocity

at each of those time points.



HANG TIME

- Estimate how long your favorite basketball player will be in the air if they can jump 1.0 m. (Remember – the hang time will be the amount of time it takes the player to go up and down!)

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

$v_i = 0$

$x_i = 0$

$$1.0m = \frac{1}{2}\left(-\frac{9.8m}{s^2}\right) t^2$$

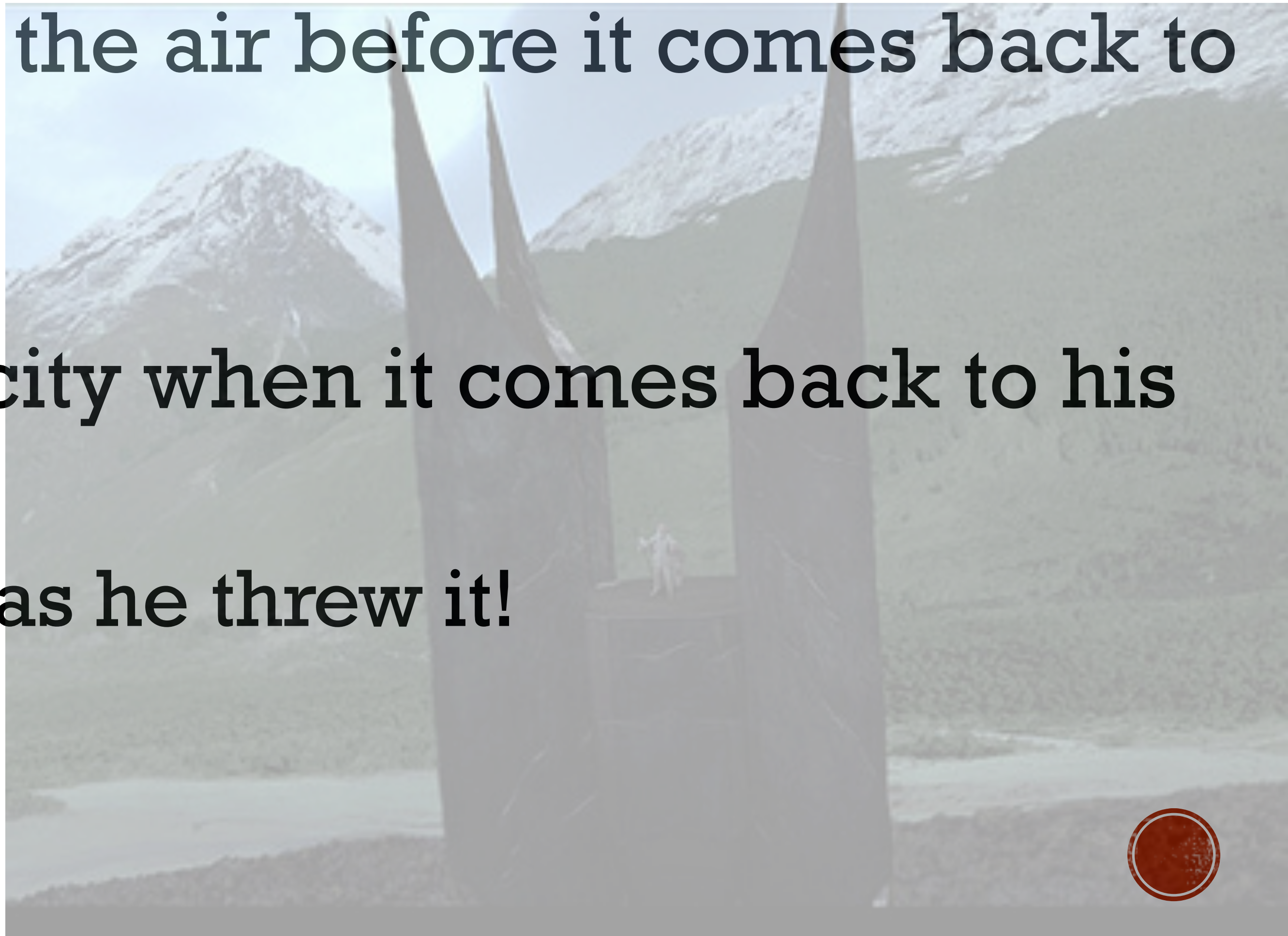
½ the hang time = t = 0.45 seconds

Hang time = 0.90 seconds

STRATEGIES FOR SOLVING A KINEMATICS PROBLEM

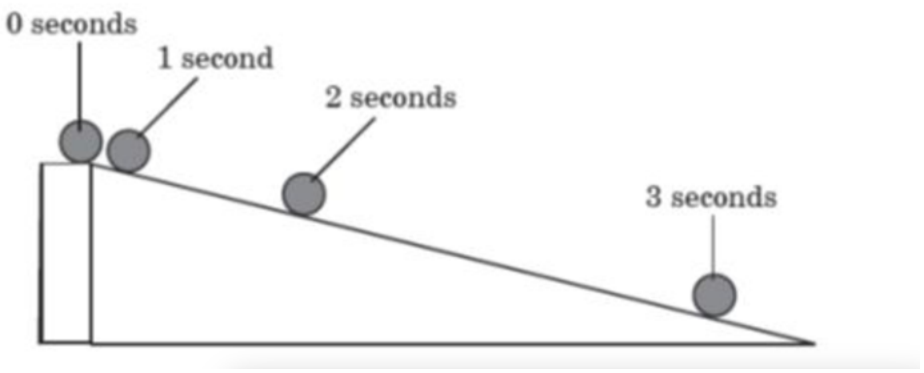
- *Draw it out first*
- *Figure out your **unknowns**/what you are solving for*
- *Write down your **knowns/givens***
- *Make sure everything is in the right **units***
- ***Find the equation** that best fits your unknowns and knowns*
- ***Solve**!*

- Saruman now throws the ball *upward* at 3.00 m/s
- How high does the ball go?
  - 0.459 m
- How long is the ball in the air before it comes back to his hand?
  - 0.612 s
- What is the ball's velocity when it comes back to his hand?
  - -3.00 m/s – the same as he threw it!



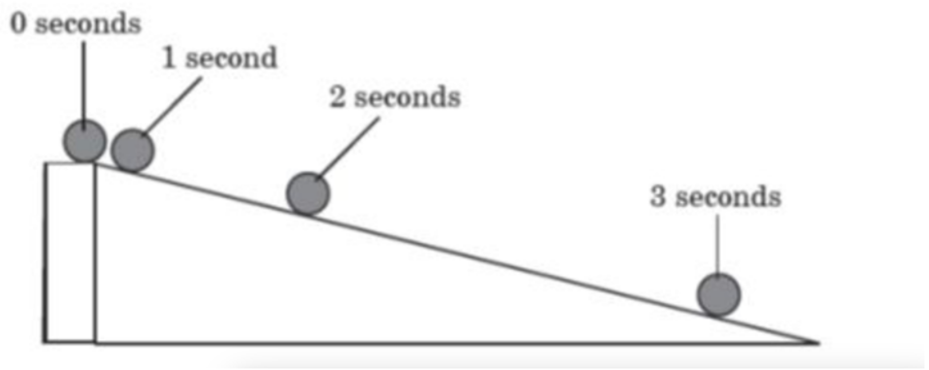
GALILEO'S RAMPS

- In addition to dropping objects off the Tower of Pisa, Galileo also measured acceleration by rolling balls on "inclined planes"

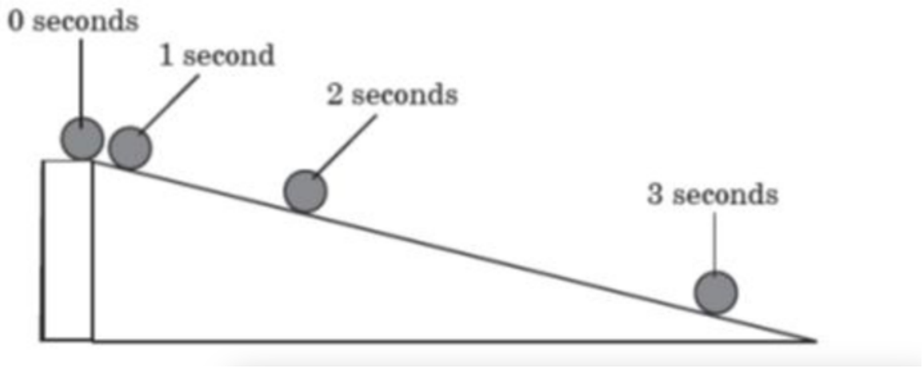


GALILEO'S RAMPS

- He noticed that a ball rolling down an inclined plane will **pick up the same amount of speed in successive seconds**



- For example, a ball rolling down a plane at a certain angle picks up 2 m/s every second it rolls
- Instantaneous velocity at 1-second intervals may be 0, 2, 4, 6, 8…m/s
- **Instantaneous velocity = acceleration * time passed**



GALILEO'S RAMPS

- The steeper the plane, the higher acceleration the ball experiences