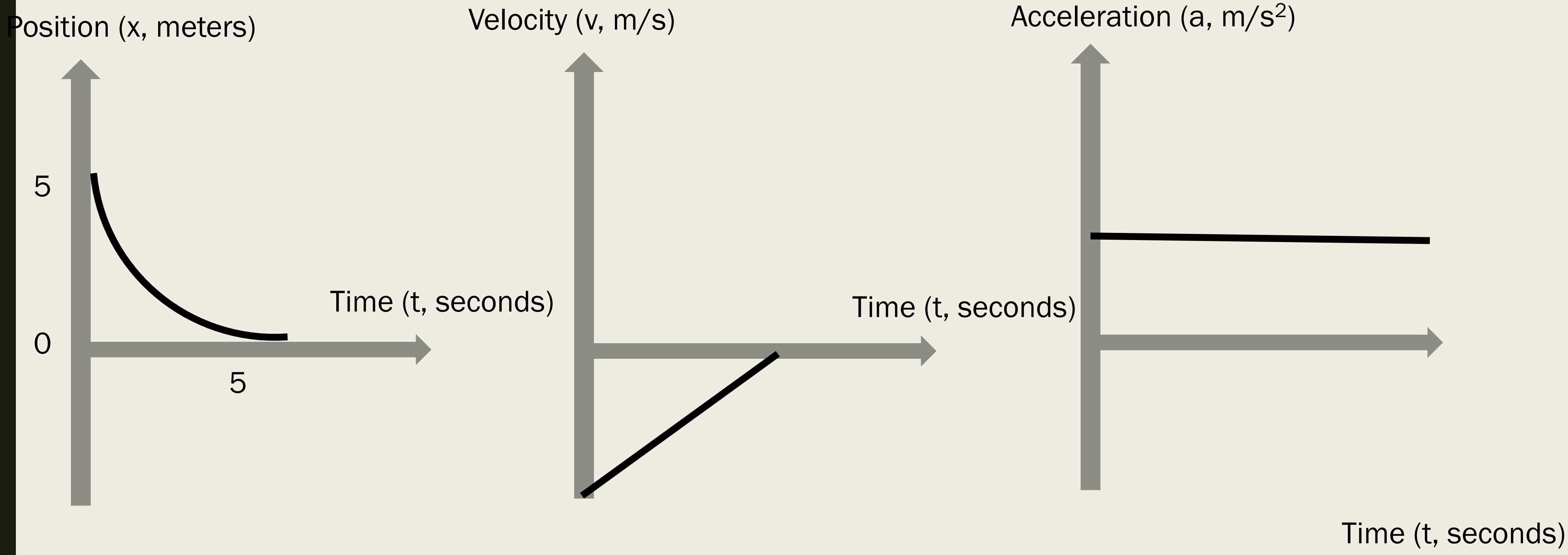

Position (x, meters)
5
0
5
Time (t, seconds)
Velocity (v, m/s)
Time (t, seconds)
Acceleration (a, m/s2)
Time (t, seconds)

Goals for Today

- Quiz time!
- Kinematic equations
- Freefall

Lab Tomorrow!

- Bring a straight edge and graph paper

Motion at constant acceleration

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

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

$$x_f = x_i + v\Delta t$$

$$v_f = v_i + a\Delta t$$

Motion at constant acceleration

- With a little simple calculus, can find acceleration's contribution to a change in position…
- $x_f = x_i + v_i \Delta t + \frac{1}{2} a \Delta t^2$
- Or $\Delta\, x = v_i \Delta t + \frac{1}{2} a \Delta t^2$
- (For the full derivation check out http://physics.info/kinematics-calculus/)

But what if there's no time??

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

Your 3 kinematic equations

$$v_f = v_i + a\Delta t$$

$$(x_f = x_i + v\Delta t)$$

$$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$$

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

Strategies for solving a kinematics problem (Giancoli pg. 29)

- *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**!*

Example #1

- *Kira decelerates for 3.00 seconds from 12.0 m/s at a rate of -2.0 m/s each second. What is her final speed?*

$$v_f = v_i + a\Delta t$$

- v_f=12.0 m/s – (2.0 m/s^2)(3.00s)
- v_f=6.0 m/s

Example #2

- Just like out of a DMV video – Kay is driving on a residential street at 16 m/s when she sees a ball roll into the road 12.0m ahead and she knows a child is soon to follow. What must be her deceleration in order to stop before hitting the ball or the following child?
- $a = \frac{0-\left(\frac{16.0m}{s}\right)^2}{2*12.0m}$
- a= - 51.0 m/s^2

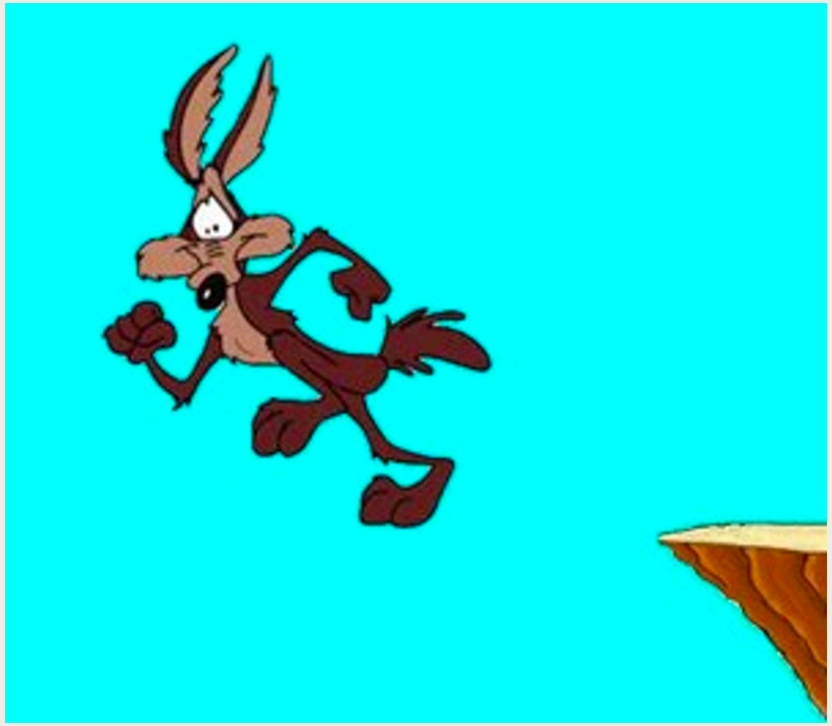
$$v_f^2 - v_i^2 = 2a\Delta x$$

Example #3

- Minimum stopping distance is important in traffic design. The average human reaction time is 0.22 s, meaning there is a 0.22 s delay between when one decides to break and when he or she actually begins breaking. A typical car can decelerate at 6.0 m/s^2 in good conditions. Knowing this, calculate the total stopping distance in meters for a vehicle that is traveling at 100. km/h.
- Ans. 71 m

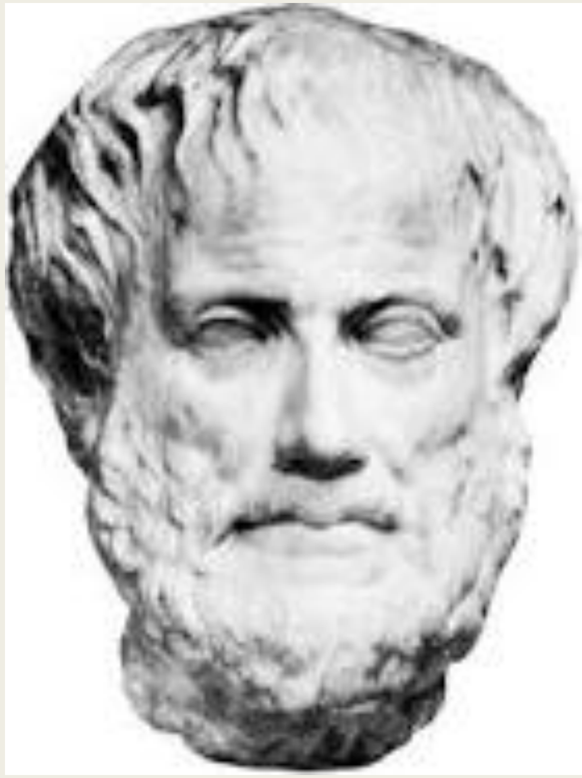
Freefall

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



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

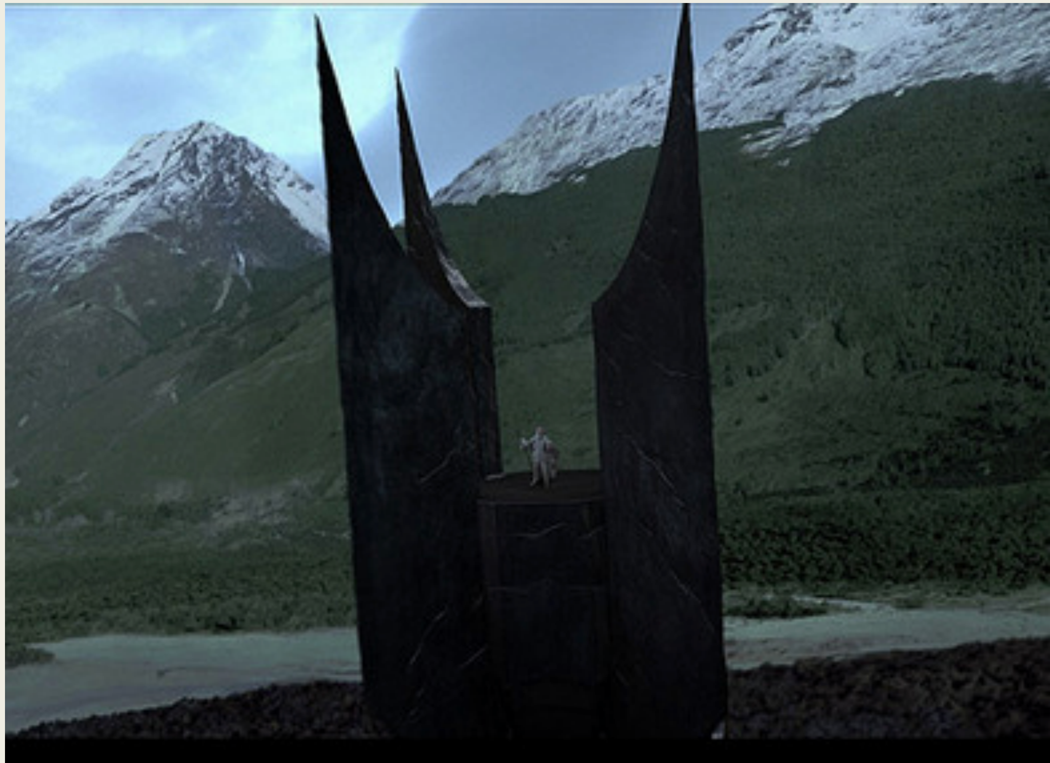
- Then Galileo showed up, dropped some masses off the Leaning Tower of Pisa, and came to an interesting conclusion…

- **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.**
  - While a feather may land after a bowling ball, this difference is due to air resistance.

Calculations with Freefall

- Kinematic equations stay the same, but now *g* replaces *a*, where *g* = 9.81m/s^2, but you have to change the sign because *g* points down.
- $\Delta x = v_i t + \frac{1}{2}at^2 \Longrightarrow \Delta x = v_i t - \frac{1}{2}gt^2$

- Saruman is conducting physics experiments from atop the Tower of Orthanc.
- If he drops his seeing stone (a ball) from the peak of his 150-m-tall fortress, how far will the ball have fallen after 1.00 s, 2.00 s, and 3.00 s? (Neglect air resistance)
- Ans. 4.90 m
- 19.6 m
- 44.1 m



- 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

Hang time

- Estimate how long your favorite basketball player will be in the air if they can jump 1 m.

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

v_i=0

$$1m = -\frac{1}{2} g t^2$$