ACCELERATION

Review

- Remember that:
- Speed is a measure of distance over time
  - How long it takes you to get from one place to another
- Velocity was speed in a direction

Scalar vs Vector

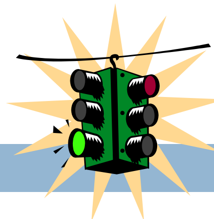
- **Scalar** (Just a number)
  - Distance
  - Speed
  - **Magnitude of Acceleration**

- **Vector** (A Number and A Direction)
  - Displacement
  - Velocity
  - **Acceleration**

What is acceleration?

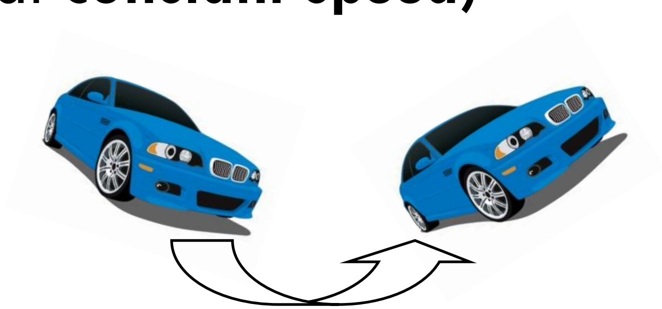
- **Acceleration** is the rate of change of velocity.
- A change in velocity can be caused by:
  - Change in speed
    - Speed up or slow down
  - Change in direction

3 ways to cause acceleration



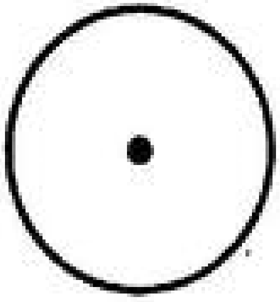
- Increasing speed
  - Example: Car speeds up at green light

- Decreasing speed
  - Example: Car slows down at stop light
- Changing Direction
  - Example: Car takes turn (can be at **constant speed**)



Zero Acceleration

- For acceleration to be zero, the velocity cannot be changing
- ONLY when you are traveling at a constant speed in one direction
- So, would it still be zero if you were traveling at a constant speed in a circle?



The Math

- Acceleration = a = change in velocity divided by the change in time
  - $A = \frac{V_f - V_i}{t}$

- Units = m/s^2
- m/s^2 ALWAYS means acceleration

FORMULAS:

- $$A = \frac{V_f - V_i}{t}$$
- $$T = \frac{V_f - V_i}{A}$$
- $$V_f = (A \times t) + V_i$$

The numbers never lie…

- A SMALL acceleration means velocity is increasing gradually
- A LARGE acceleration means velocity is increasing rapidly

- A POSITIVE acceleration means an object is speeding up
- A NEGATIVE acceleration means an object is slowing down
  - This is called **deceleration**

Example

- You are driving from school home and your velocity goes from 10 m/s to 40 m/s in 5 secs.

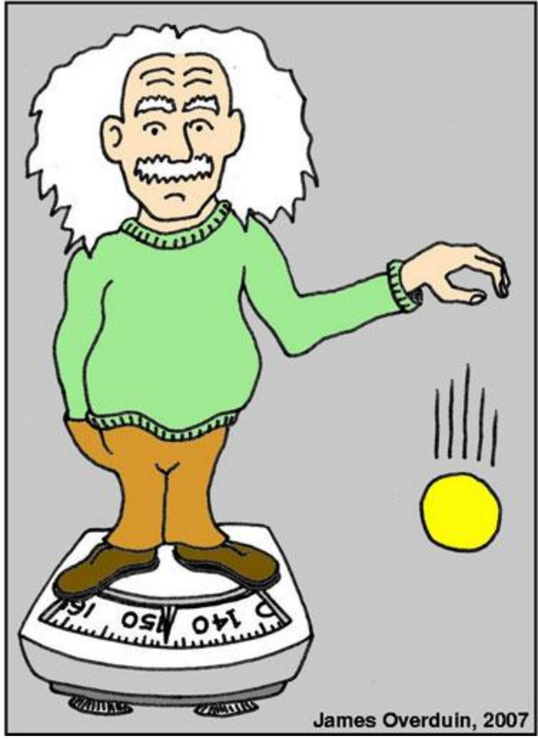
- What is your acceleration?

Example

- If a football is thrown from rest with an acceleration of $8.5\ m/s^2$, and had an final velocity of $25 m/s$, how long was the football accelerating?

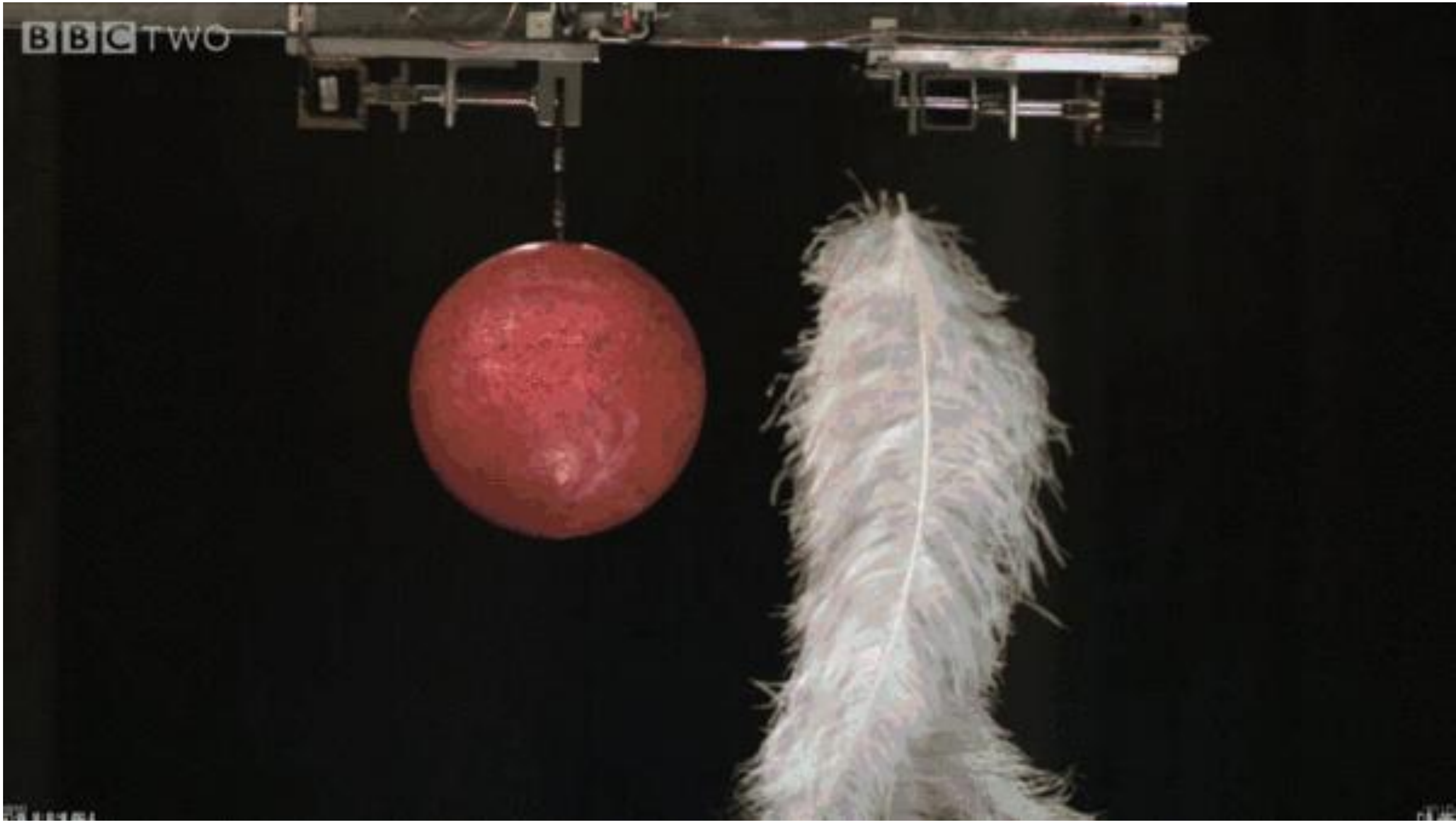
Gravity and Acceleration

- Gravity is the force that pulls everything toward the center of the Earth
  - Acceleration due to Gravity = $9.8 m/s^2$



- In a vacuum, things fall towards the earth at $9.8 m/s^2$ every second
  - A vacuum is a space entirely void of matter
  - When not in a vacuum, air resistance will slow down a falling object.

Ball and a Feather in a Vacuum



Gravity and Slinky!

- Just cuz it looks cool…

- The top of the slinky
Is falling, but the bottom
Of the slinky is trying
To recoil back to the top
Of the slinky.

Gravity and People!

- Amazing…

Falling From Space

http://www.youtube.com/watch?v=dOoHArAzdug

- In a vacuum, things fall towards the earth at 9.8m/s^2 every second
  - Jumps from over 24 MILES up
    - At exactly 1 second, traveling at 9.8m/s
    - At exactly 2 seconds, traveling at 19.6m/s
    - At exactly 5 seconds, traveling at 49m/s

Gravity and Acceleration

- In real life, sometimes wind resistance causes objects to stop accelerating and reach a maximum velocity
  - This is what causes “Terminal Velocity”
  - Terminal Velocity for a falling Human is ~56 m/s (~120mi/hr)

TERMINAL VELOCITY

Law of Universal Gravitation

- Technically, gravity pulls everything towards everything else
  - Every object exerts a gravitational pull on every other object. But the pulls aren't all equal. They depend on a few things

- The gravitational force between two objects depends on 2 things:
  - The **MASS** of the both objects
    - As the masses increase, the gravitational force INCREASES
  - The **DISTANCE** between the two objects
    - As the distance increases, the gravitational force DECREASES.

Universal Gravitation: Math

$$F_{gravity} = \frac{Gm_1 m_2}{r^2}$$

- M_1 = mass of object 1
- M_2 = mass of object 2
- r = distance between 2 objects
- G = universal gravitational constant

  = 6.6726×10^{-11} N-m^2/kg^2

What is the gravitational force between you (at 150lbs) and the earth?

- $F = \frac{G (M_1 * M_2)}{r^2}$
- $F = \frac{6.67428 \times 10^{-11} Nm^2/kg^2 (5.97219 \times 10^{24} \text{ kg} * 75\text{kg})}{6378100m^2}$
- F = 9.8017N

Universal Gravitation: Math

Compare that to 2 students that each have a mass of 135lbs and are only 1m apart.

- $F = \frac{G (M_1 * M_2)}{r^2}$
- $F = \frac{6.67428 \times 10^{-11 Nm^2/kg^2} (75 \text{ kg} * 75 \text{kg})}{1m^2}$
- F = 1.001x10-8N OR 0.000000010011 N

Compare that to gravitational force between you (at 150lbs) and the earth?

F = 9.8017N