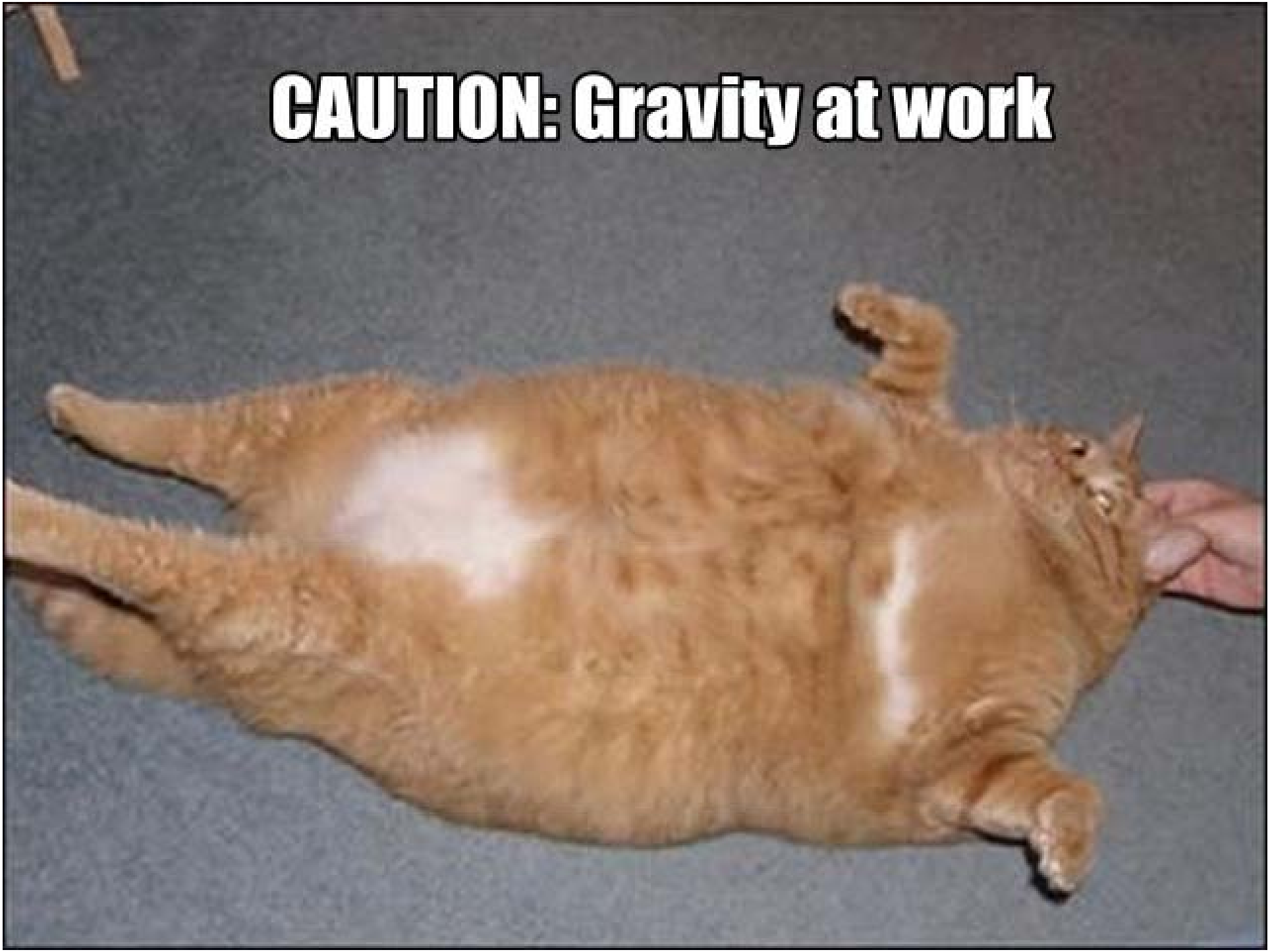

CAUTION: Gravity at work

What is Gravity?

- Write down anything you may know about gravity.
- Any examples of gravity
- Where you may find it or not find it!

What is Gravity?

- Gravity is an *attraction* that acts between any two objects that have a mass.

- However, this is only significant if one or both of the objects are very massive (like a planet, star, or moon).

An example of Gravity

- Gravity is why an apple falls from a tree.
- Why?
- Every object applies a gravitational force to every other object.
- When an apple falls (after the stem breaks) because the gravitational force between the apple and earth is much greater than the gravitational force between the apple and the tree.

Differences Between Gravity and Friction

- The force of gravity acts even when objects are not touching.
- The force of friction can never make an object speed up!
- Friction always points opposite the direction of motion, but sometimes gravity points in the direction of motion.

Mass and Distance

- Mass and Distance affect Gravitational Force.

- The force of gravity between two objects depends on their masses and on the distance between the two objects.

More about Gravity

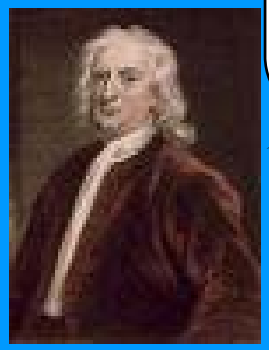
- The greater the mass of an object, the larger the gravitational force it applies on other objects.

- Also, as the distance between two objects increases, the gravitational force between them decreases.

Gravitational Force Formula

$$F_G = \frac{G \times mass_1 \times mass_2}{distance^2}$$

$$F_G = \frac{G \times m_1 \times m_2}{d^2}$$



My name is Sir Isaac Newton and I figured this out!

d is the distance *between the centers* of the two objects.

G is called the "gravitation constant" it equals 6.673×10^{-11} N x m^2/kg^2 and makes the units right!

More about Gravity

Gravity is the reason why weight and mass are two different measurements!!!

Mass is *related to* the amount of matter in an object.

Weight = the force of gravity pulling on any object. (w=mxg)

So…which one would change if you were on the moon? Why?

***Weight,* because the force of gravity pulling on an object on the moon is only 1/6 of that on the Earth!**

QUESTION????

- Which pair has more gravitational force…you and your neighbor or you and the earth?
- How? (Use the formula… $F_G = G \times m_1 \times m_2/d^2$)

- You (60.4 kg) and your neighbor (70.5 kg) and d=1.5 m

$$F_G = \frac{\left(6.673 \times 10^{-11} \text{N} \times \text{m}^2/\text{kg}^2\right) \times 70.5 \text{ kg} \times 60.4 \text{ kg}}{(1.5\text{m})^2} = 1.26 \times 10^{-7} \text{N}$$

- You (60.4 kg) and the earth (5.9742×10^{24} kg)

$$F_G = \frac{\left(6.673 \times 10^{-11} \text{N} \times \text{m}^2/\text{kg}^2\right) \times \left(5.97 \times 10^{24} \text{ kg}\right) \times 60.4 \text{ kg}}{\left(6378100 \text{ m}\right)^2} = 592 \text{ N}$$

- But what is your weight?

$$w = m \times g = 60.4 \text{ kg} \times 9.8 \text{ m/s}^2 = 592 \text{ N}$$

They're the same!
… but how?!?!?!

The Acceleration Due to Gravity:

- We can calculate it! At ground level:

$$F_G = \frac{(6.673 \times 10^{-11}\ \mathrm{N \times m^2/kg^2}) \times (5.97 \times 10^{24}\ \mathrm{kg}) \times 60.4\ \mathrm{kg}}{(6378100\ \mathrm{m})^2}$$

What's this?

$9.80\ \mathrm{m/s^2} = g$

But we can calculate "g" anywhere, caused by any object with mass!

$$g = \frac{G \times m}{d^2}$$

The Acceleration Due to Gravity:

- **How does g change with altitude?**

Altitude (m)	Distance From the Center of the Earth (m)	g due to the Earth's Gravity (m/s^2)	What has This Altitude?
0	6378100	9.799823	
2	6378102	9.799817	Height of a person
4	6378104	9.799811	
137	6378237	9.799402	Highest point in Delaware
381	6378481	9.798652	Empire State Building
8848	6386948	9.772690	Height of Mount Everest
12000	6390100	9.763051	Airplane
340000	6718100	8.832994	International Space Station
6378100	12756200	2.449956	Twice the Earth's Radius
378024900	384403000	0.002698	The Moon

The Acceleration Due to Gravity:

- So what is g for the moon, on the surface of the moon?

$$g_{moon} = \frac{G \times m_{moon}}{(d_{moon})^2}$$

$$g_{moon} = \frac{(6.673 \times 10^{-11} N \times m^2/kg^2) \times (7.3477 \times 10^{22}\ kg)}{(1737100\ m)^2}$$

$$g_{moon} = 1.62\ m/s^2$$

Gravity Practice Problems

1) $m_1 = 15$ kg
   $m_2 = 996$ kg
   $d = 596$ m

2) $m_1 = 232$ kg
   $m_2 = 9{,}456$ kg
   $d = 56$ m

3) $m_1 = 600$ kg
   $m_2 = 72{,}684$ kg
   $d = 30$ m

4) $m_1 = 7.35 \times 10^{22}$ kg
   $m_2 = 5.97 \times 10^{25}$ kg
   $d = 3.84 \times 10^{8}$ m

D	U	F	A
$m_1 = 15\ kg$ $m_2 = 996\ kg$ $d = 596\ m$ $G=6.673x10^{-11}$ $N*m^2/kg^2$		$F_G = \frac{G \times m_1 \times m_2}{d^2}$	$F_G = \frac{G \times m_1 \times m_2}{d^2}$

S

$$F_G = \frac{\left(6.673 \times 10^{-11}\ N \times m^2/kg^2\right) \times 15\ kg \times 996\ kg}{\left(596\ m\right)^2}$$

$$F_G = \frac{\left(9.97 \times 10^{-7}\ N \times m^2\right)}{355216\ m^2}$$

$$F_G = 2.81 \times 10^{-12}\ N$$

D	U	F	A
m_1= 232 kg m_2= 9,456 kg d = 56 m G=6.673x10^{-11} N*m^2/kg^2		$F_G = \frac{G \times m_1 \times m_2}{d^2}$	$F_G = \frac{G \times m_1 \times m_2}{d^2}$
S	$F_G = \frac{\left(6.673 \times 10^{-11} N \times m^2/kg^2\right) \times 232\ kg \times 9456\ kg}{\left(56\ m\right)^2}$ $F_G = \frac{\left(1.46 \times 10^{-4} N \times m^2\right)}{3136\ m^2}$ $F_G = 4.67 \times 10^{-8} N$		

D	U	F	A
m_1 = 600 kg m_2 = 72,684 kg d = 30 m G= 6.673×10^{-11} $N*m^2/kg^2$		$F_G = \frac{G \times m_1 \times m_2}{d^2}$	$F_G = \frac{G \times m_1 \times m_2}{d^2}$
S	$F_G = \frac{\left(6.673 \times 10^{-11} N \times m^2/kg^2\right) \times 600 kg \times 72684 kg}{\left(30 m\right)^2}$ $F_G = \frac{\left(2.91 \times 10^{-3} N \times m^2\right)}{900 m^2}$ $F_G = 3.23 \times 10^{-6} N$		

D	U	F	A
$m_1 = 7.35\times10^{22}$ kg $m_2 = 5.97\times10^{25}$ kg d = 3.84×10^{8} m $G=6.673x10^{-11}$ $N*m^2/kg^2$		$F_G = \frac{G \times m_1 \times m_2}{d^2}$	$F_G = \frac{G \times m_1 \times m_2}{d^2}$

S

$$F_G = \frac{\left(6.673\times10^{-11}\text{N}\times\text{m}^2/\text{kg}^2\right)\times\left(7.35\times10^{22}\text{ kg}\right)\times\left(5.97\times10^{25}\text{ kg}\right)}{\left(3.84\times10^{8}\text{ m}\right)^2}$$

$$F_G = \frac{\left(3.84\times10^{8}\text{ N}\times\text{m}^2\right)}{1.47\times10^{17}\text{ m}^2}$$

$$F_G = 1.99\times10^{21}\text{ N}$$