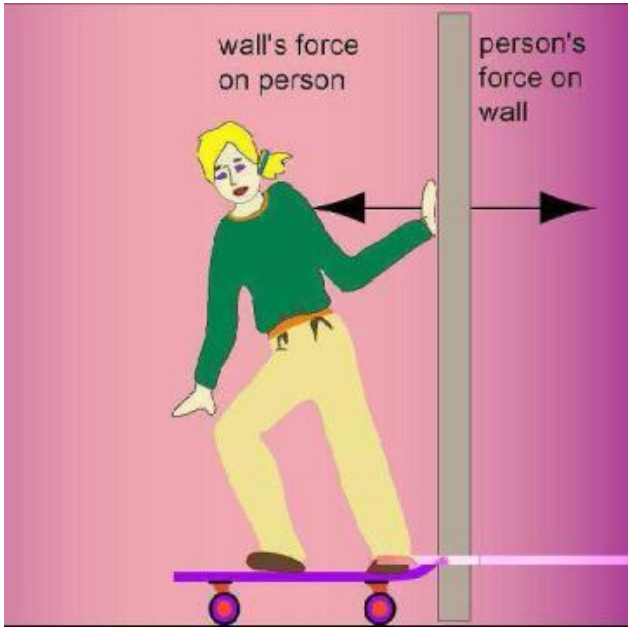
Newton's 3rd Law and Law of Gravitation

Washington Physics

Newton's Third Law

"For every action there is an EQUAL and OPPOSITE reaction.

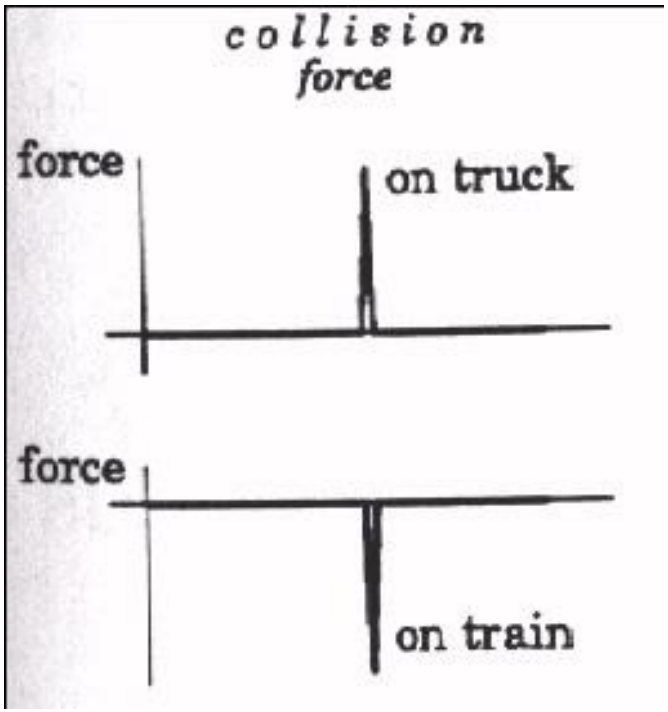
- This law focuses on action/reaction pairs (forces)
- They NEVER cancel out



All you do is SWITCH the wording!

- PERSON on WALL
- WALL on PERSON

N.T.L



This figure shows the force during a collision between a truck and a train. You can clearly see the forces are EQUAL and OPPOSITE. To help you understand the law better, look at this situation from the point of view of Newton's Second Law.

$$F_{Truck} = F_{Train}$$

$$m_{Truck}A_{Truck} = M_{Train}a_{Train}$$

There is a balance between the mass and acceleration. One object usually has a LARGE MASS and a SMALL ACCELERATION, while the other has a SMALL MASS (comparatively) and a LARGE ACCELERATION.

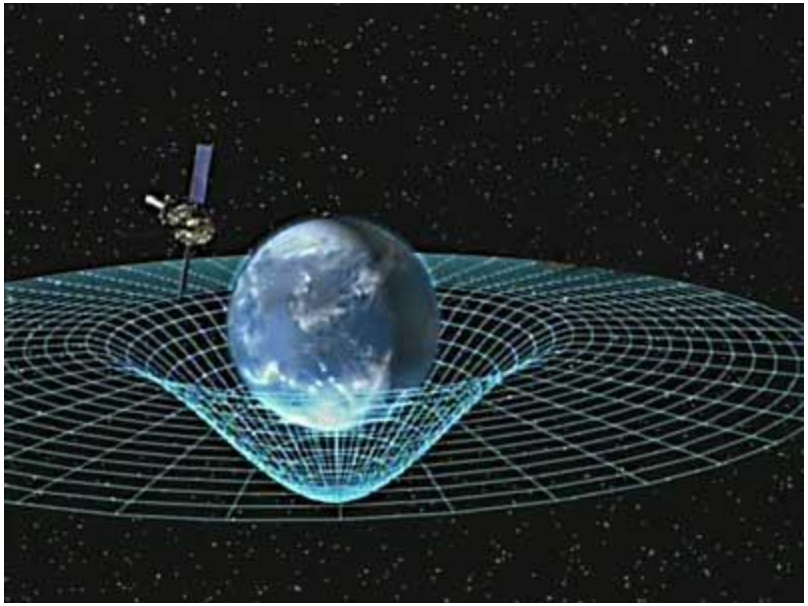
N.T.L Examples

Action: HAMMER HITS NAIL
Reaction: NAIL HITS HAMMER

Action: Earth pulls on YOU
Reaction: YOU pull on the earth

Newton's Law of Gravitation

What causes YOU to be pulled down? THE EARTH….or more specifically…the EARTH'S MASS. Anything that has MASS has a gravitational pull towards it.



$$F_g \alpha Mm$$

What the proportionality above is saying is that for there to be a FORCE DUE TO GRAVITY on something there must be at least 2 masses involved, where one is larger than the other.

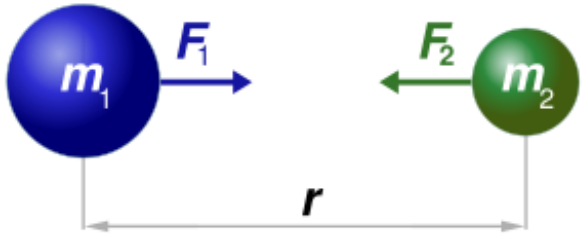
N.L.o.G.

As you move AWAY from the earth, your DISTANCE increases and your FORCE DUE TO GRAVITY decrease. This is a special INVERSE relationship called an Inverse-Square.

$$F_g \alpha \frac{1}{r^2}$$

The “r” stands for SEPARATION DISTANCE and is the distance between the CENTERS OF MASS of the 2 objects. We us the symbol “r” as it symbolizes the radius. Gravitation is closely related to circular motion as you will discover later.

N.L.o.G – Putting it all together



$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

$$F_g \ \alpha \ \frac{m_1 m_2}{r^2}$$

G = constant of proportionality

G = Universal Gravitational Constant

$$G = 6.67x10^{-11}\ Nm^2/kg^2$$

$$F_g = G\frac{m_1 m_2}{r^2}$$

$F_g = mg \rightarrow$ Use this when you are on the earth

$F_g = G\frac{m_1 m_2}{r^2} \rightarrow$ Use this when you are LEAVING the earth

Try this!

Let's set the 2 equations equal to each other since they BOTH represent your weight or force due to gravity

$$F_g = mg \rightarrow \text{Use this when you are on the earth}$$

$$F_g = G\frac{m_1 m_2}{r^2} \rightarrow \text{Use this when you are LEAVING the earth}$$

$$mg = G\frac{Mm}{r^2}$$

$$g = G\frac{M}{r^2}$$

$$M = \text{Mass of the Earth} = 5.97x10^{24} - kg$$

$$r = \text{radius of the Earth} = 6.37x10^{6} - m$$

SOLVE FOR g!

$$g = \frac{(6.67x10^{-11})(5.97x10^{24})}{(6.37x10^{6})^2} = 9.81 m/s^2$$