Forces

Tuesday, March 08, 2016 8:28 AM

May the Forces be With Us

There are many forces acting on us at all times. Today, we're going to define and name some of the forces that we will be working with in this unit.

The force of gravity is working on you right now. If you are being accelerated downward at 9.8 $\frac{m}{s^2}$ then why are you stationary at your desk?

Many of the forces acting on you cancel eachother out. It is when we have an unbalanced force that we measure and calculate its effect. This is called the net force (F_{net}).

A force is any push or pull. Forces are measured in newtons (N). A newton is a derived unit (a combination of SI base units to make another unit) because physicists are inherently lazy and don't want to write $\frac{kg*m}{s^2}$ every question. Instead, they write, N.

Force of Gravity:

We have seen this one a lot. It comes directly from Newton's second law (more on that tomorrow!)

The force of gravity is equal to the mass of the object times the acceleration due to gravity.

$-9.8 \frac{m}{s^2}$

$$F_g = mg$$

'g' is a constant from near Earth objects. It is only for use near Earth (within a few dozen km's [on the ISS (400km) 'g' would be 8.8 $\frac{m}{s^2}$ - pretty close still]).

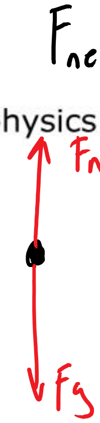
eg: What is the force of gravity on a typical physics student of 88kg?

$F_g = (88)(-9.8)$

$= -862$ N

Normal Force:

Normal in the language of mathematics means perpendicular. This is the force that acts perpendicular (normal) on an object at rest. You are being accelerated down towards the center of the Earth right now. You are not moving because the normal force is acting on your bum through your chair.

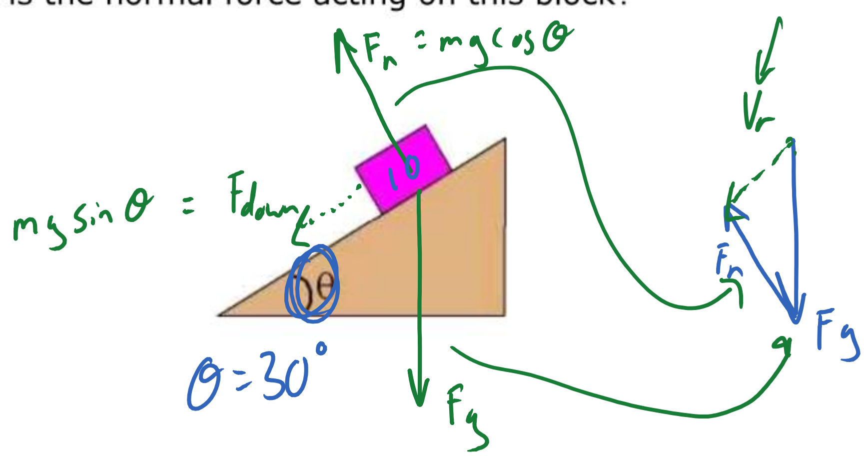


eg: What is the normal force acting on our physics student in the above example?

$F_g = 862\,N$

$F_n = 862\,N$

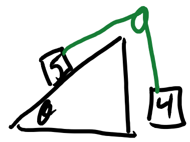
eg: What is the normal force acting on this block?



$F_n = mg\cos\theta$
$= (10)(-9.8)\frac{\sqrt{3}}{2}$
$= -84.9\,N$

Force of Friction:

This is the force cased when molecules interact with each other. It is the reason that we move around, it is also the force that works in opposition of intended motion.



$$F_f = \mu F_N$$

μ - pronounced "MEW" is called the coefficient of friction. It is basically a numerical representation of how sticky something is. Close to zero - very slippery. Imagine putting zero in the above equation - F_f would go to zero as well. Numbers around one are very sticky. (glue, rubber)

eg: When a road is wet it becomes very slippery. μ=0.20. If I drive a 1,000kg vehicle on this road, what is the F_f?

$$F_f = \mu F_n$$
$$= (.2)(1000)(9.8)\cos(0)$$
$$= 1960\,N$$

eg: Compare this to a dry road. μ=0.60

$$F_f = .6(1000)(9.8)$$
$$= 5880\,N$$

How many times more force of friction is on a dry road to a wet road?

$$\frac{F_{f-Dry}}{F_{f-wet}} = \frac{5880}{1960} = 3$$

Elastic Force:

This force restores an object to its original form after being stretched. Imagine this with a bow and arrow, a rubber band, or a spring.

$$F_e = kx$$

'k' is a constant and it is different for every object.
Objects will spring back to their original shape as long as they are not pulled beyond their elastic limit.

eg: A rubber band of length 15cm and a spring constant of 12 $\frac{N}{m}$ experiences a force of 0.05N. What is the amount it stretches?

$F_e = kx$

$.05 = 12x$

$\frac{.05}{12} = x = 4mm$

$m = x10^{-3}$

What is its new length?

15cm + 4mm =

150mm + 4mm = 154mm

Universal Gravitation:

Remember that whole 9.8 $\frac{m}{s^2}$ thing that we keep saying is only good near Earth? This is the real, full equation:

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

G is the universal gravitational constant $= 6.67x10^{-11} \frac{Nm^2}{kg^2}$
We get the F_g for near earth objects by filling in the mass of the Earth and the radius of the Earth.

It's different away from the Earth though...

117 lb · $\frac{1 \text{ kg}}{2.2 \text{ lb}}$ = 53 kg

Calculate the force of gravity on [who will volunteer their weight in kg] on the Earth and the moon?

$$F_g = G \frac{(5.97 \times 10^{24})(53)}{(6371 \times 10^3)^2} = 520N$$

Kyle and Devon are obviously attracted to each other. Let's see by how much.

$$F_{g-Kyle/Devon} = \sout{1.667} \times 10^{-11} \frac{m_1 m_2}{r^2}$$

6.67

m_{Kyle} = 150 lb

m_{Devon} = 125 lb

r = .5m

~~F_g = 1.24 uN~~

F_g = 1.03 uN