Gravitational force

Gravity is an attractive force between any 2 masses.

On Earth...

$F = ma$ but $a = g$

$\therefore \boxed{F_g = mg}$

Weight = force of gravity on an object

Mass = amount of matter

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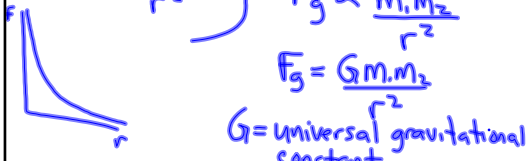
In general

$F_g \propto m_1 m_2$

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



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

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

G = universal gravitational constant

$[N] = \left[\frac{N m^2}{kg^2}\right]\frac{[kg][kg]}{[m^2]} = 6.67 \times 10^{-11}\ \frac{N m^2}{kg^2}$

Ex. What is the gravitational force between you and the person sitting next to you?

$r = 0.7$ m

$m_1 = 60$ kg

$m_2 = 70$ kg

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

$= \frac{(6.67 \times 10^{-11})(60)(70)}{(0.7)^2}$

$F_g = 5.71 \times 10^{-7}$ N

60 kg...

$a = \frac{F}{m}$

$= \frac{5.71 \times 10^{-7}}{60}$

70 kg

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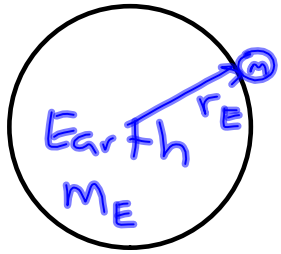
We can use this to get g



$F_g = \frac{G m_E m}{r^2}$ $F_g = mg$

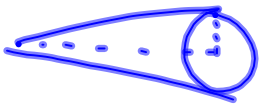
$F_g = 9.8m$

$\therefore mg = \frac{G m_E m}{r^2}$

$m_E = 5.98 \times 10^{24}$ kg

$r_E = 6.38 \times 10^6$ m

$g = \frac{G m_E}{r_E^2}$



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The Normal Force

'Normal' means "at right angles"

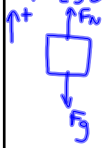
$F_N \rightarrow$ ⊥ the surface

(perpendicular to)

→ meant to stop object from going through surface

Ex.

A 250 g book sits on a desk...



$F_{NET} = ma$

$= 0$

$F_{NET} = \sum F$

$= F_N - F_g$

$\therefore 0 = F_N - F_g$

$\therefore F_N = F_g$

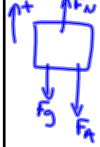
$= mg$

$= (0.25)(9.8)$

$= 2.45$ N

$m = 250$ g $= 0.25$ kg

If you push down on the book with a force of 5 N...



$F_{NET} = 0$

$F_{NET} = F_N - F_g - F_A$

$\therefore F_N - F_g - F_A = 0$

$F_N = F_g + F_A$

$= mg + 5$

$= (0.25)(9.8) + 5$

$= 7.45$ N

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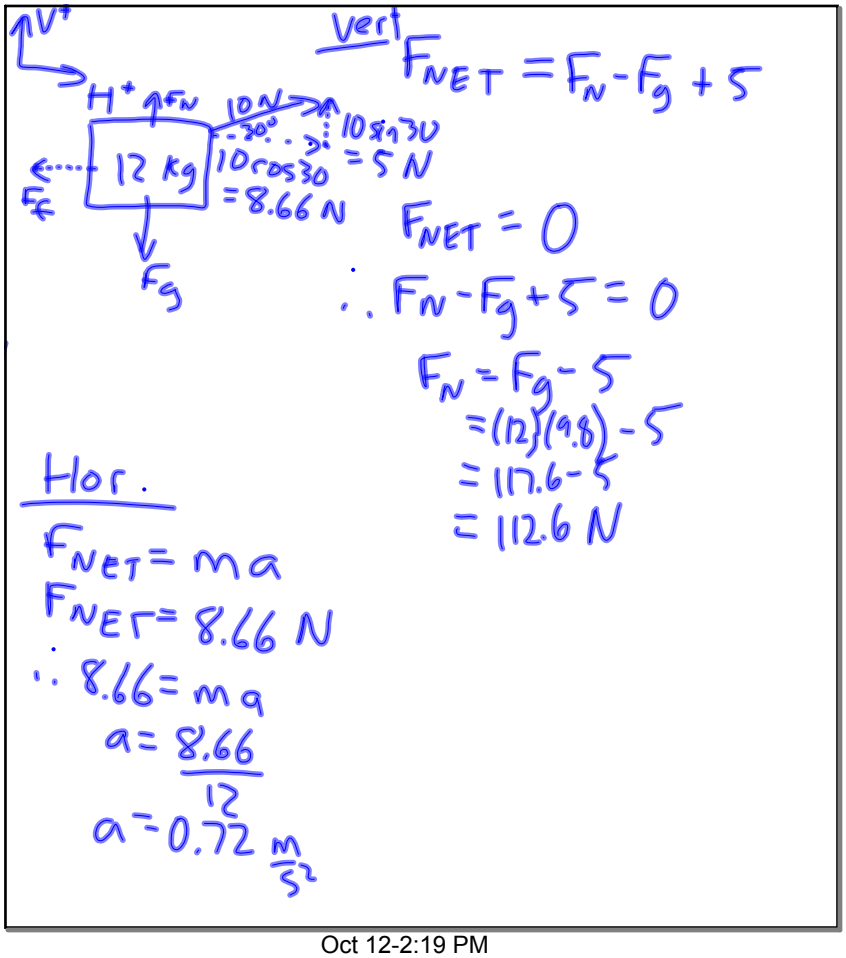

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Friction

Friction is a resistive force that occurs between 2 surfaces.

resistive → always ~~opposes~~ motion

2 types of friction:

Static	Kinetic
- surfaces are not moving against each other	- surfaces slide along each other
Eg. - car is parked - car is driving (under control)	- car is skidding
Always at least as large as Kinetic	Smaller than Static

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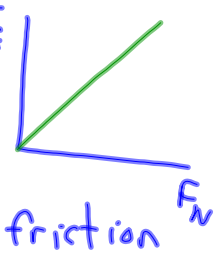
F_f is affected by...
... the 2 surfaces in contact
... the normal force

$F_f \propto F_N$

$F_f = \text{constant} \times F_N$

μ coefficient of friction



Examples

Surfaces	μ_k	μ_s
steel on steel, dry	0.41	0.6
greesy	0.12	
rubber-asphalt		
dry	1.07	
wet	0.95	
rubber-concrete		
dry	1.02	
wet	0.97	

$F_f = \mu F_N$

$\mu = \frac{F_f}{F_N}$

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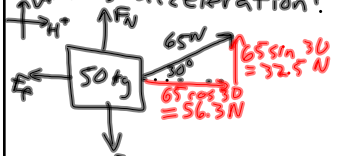
Example:
A skier is being pulled by a cable with a force of 65 N (30° above the horizontal). If the skier has a mass of 50 kg, and $\mu = 0.1$ between the skis and the snow, what is the skier's acceleration?



Vert.
$F_{NET} = 32.5 + F_N - F_g$
$F_{NET} = 0$
$\therefore 0 = 32.5 + F_N - F_g$
$F_N = mg - 32.5$
$= 457.5$ N

Hor.
$F_{NET} = 56.3 - F_f$
$F_{NET} = ma$
$\therefore 50a = 56.3 - \mu F_N$
$50a = 56.3 - (0.1)(457.5)$
$= 56.3 - 45.75$
$= 10.55$
$a = 0.21 \frac{m}{s^2}$

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