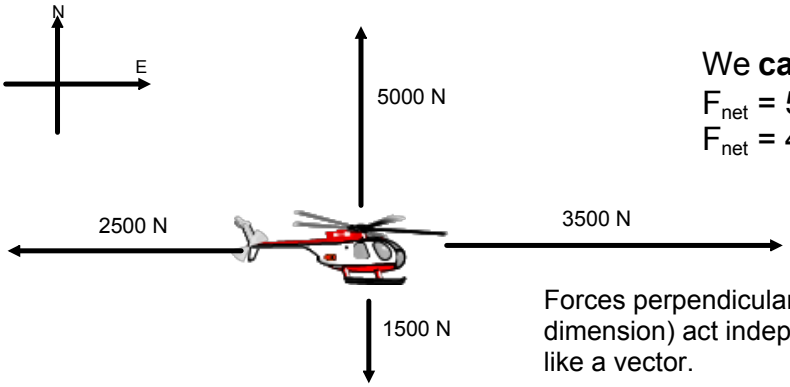
Net Force

The *net force* is the vector sum of all the forces acting on an object. Only forces acting in the same dimension (i.e. left and right or up and down) can be mathematically added (or subtracted).

Consider the four forces acting on the object below:



We **cannot** say the net force is:
F_{net} = 5000 - 1500 + 3500 - 2500
F_{net} = 4500 N

Forces perpendicular to each other (or in a different dimension) act independently on an object and must be added like a vector.

We can talk about the net force in each dimension:

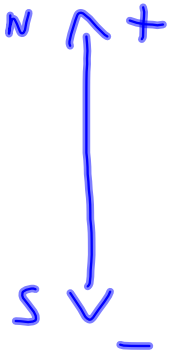
F_{net} [East] = 3500 N - 2500 N
F_{net} [E] = 1000 N

F_{net} [North] = 5000 N - 1500 N
F_{net} [N] = 3500 N

To find the actual net force on the object we would need to do a scale diagram with the vectors or a calculation (grade 12).

Often to identify which direction we are focusing on we use the subscripts x and y. Like in your math class, x - horizontal direction and y - vertical direction. Directions are all in the way your set up your problem for analysis - your frame of reference.

The force of gravity on a ball is 10 N. An upward wind acts with 14 N. What is the net force on the ball?



$F_{net} = F_g + F_{wind}$

$F_{net} = -10\,N + 14\,N$

$F_{net} = 4\,N$ (up)

The force applied to a car from the gas is 1575 N [E]. Air resistance acts with 1230 N [W]. What is the net force on the car?

$F_{net} = F_a + F_{air}$

$= 1575 - 1230$

$F_{net} = 345\,N$

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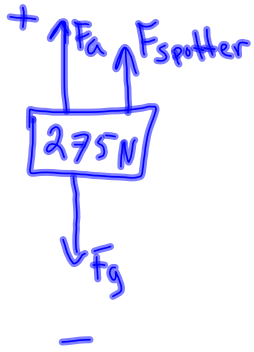
A person tries to bench press 275 N but can only lift 252 [N]. How much weight must a spotter support?



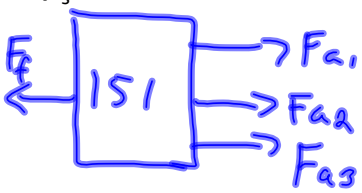
$F_{net} = F_a + F_{sp} + F_g$

$F_{net} = 0N$ (just enough to overcome gravity)

$0 = 252 + F_{sp} - 275$

$23N = F_{sp}$

Two people are supplying forces on a 151 kg box sitting on the floor. One person pushes with 144 N [E] and the other pulls with 175 N [E]. What force would a third person need to apply to start the box moving if $\mu_s = 0.33$?



$F_{net} = 0N$ (just enough to overcome friction)

$F_{net} = F_{a1} + F_{a2} + F_{a3} + F_f$

$F_{a1} = 144\ N$, $F_{a2} = 175N$, $F_{a3} = ?$, $F_f = ?$

$F_f = \mu F_N$ → Normal Force = Force gravity, mg

$F_f = \mu mg = (0.33)(151)(9.81)$

$F_f = 489\ N$

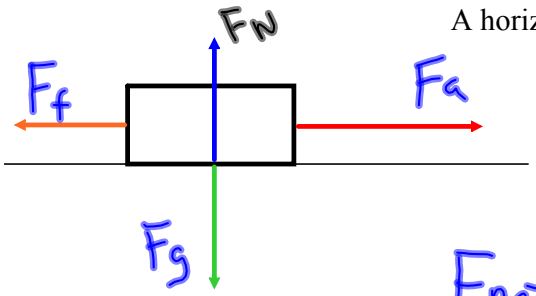
So, use the F_{net} relation:

$0 = 144 + 175 + F_{a3} - 489$

$170\ N = F_{a3}$

* Answer is positive so the direction is East.

NOTE: The net force equation is applied to different dimensions independently.



A horizontal force of 85 N is required to pull a child in a sled at constant speed over dry snow to overcome the force of friction. The child and sled have a combined mass of 52 kg. Calculate the coefficient of kinetic friction between the sled and the snow. (0.17)

$F_{net} = F_a + F_f$, $F_{net} = 0$

$F_f = \mu F_N$

Find F_f:

$0 = 85 + F_f \rightarrow -85 = F_f$

Find F_N:

$F_N = F_g = mg$

$F_N = (52)(9.81) = 510\ N$

Find μ

$F_f = \mu F_N$

$85 = \mu(510) \Rightarrow \mu = 0.17$

Always use magnitudes (positive) numbers with this formula.

1. A 62 kg crate is pulled at a constant velocity with an applied force of 337 N.
   a. Calculate the force of friction.
   b. Calculate the normal force on the crate.
   c. Calculate the coefficient of kinetic friction.

a) $F_{net} = 0\ N$ (constant velocity)

$F_{net} = F_a + F_f$ (only two forces acting in that direction)

$0 = 337 + F_f$

$-337\ N = F_f$

b) $F_N = F_g$, $F_g = mg$

$F_N = (62\ kg)(9.81\ m/s^2)$

$F_N = 608\ N$

c) $F_f = \mu F_N$ ← always use + numbers

$\mu = \frac{F_f}{F_N} = \frac{337}{608}$

$\mu = 0.55$

2. A box has a weight of 625 N and is being pulled with a net force of 12 N. The coefficient of kinetic friction is 0.23.

a. What is the mass of the box?

b. What is the force of friction?

c. What is the applied force?

a) $F_g = mg$

$625 = m(9.81)$

$63.7\ kg = m$

b) $F_f = \mu F_N$

$F_N = F_g$

So, $F_f = (0.23)(625)$

$F_f = 144\ N$

↑ this is the magnitude of the force.

c) $F_{net} = F_a + F_f$

$12 = F_a - 144$

↑ F_f always opposite motion of object.

$156\ N = F_a$

3. A box is being pulled across the floor at a constant velocity with an applied force of 284 N. The coefficient of kinetic friction is 0.11.

a. What is the force of friction?

b. What is the force of gravity on the box?

c. What is the mass of the box?

a) $F_{net} = 0\ N$ $\quad F_{net} = F_a + F_f$

$0 = 284 + F_f$

$-284\ N = F_f$

b) $F_g = ?$ remember $F_g = F_N$

So $F_f = \mu F_g$

$284 = (0.11) F_g$ $\rightarrow$ $F_g = 2580\ N$

c) $m = ?$

$F_g = mg$

$2580\ N = m(9.81)$

$263\ Kg = m$

Force Practice:
Worksheets #1 & #2