

Solving Problems with Common Forces

Understanding the concepts discussed thus far is the key to solving mathematical problems involving forces. Along with the strategies we previously used there are a couple more we can use for forces:

- Free Body Diagram.
- Sketch/label a diagram showing forces.

A Note about Motion and Forces

When the net force on an object is zero, it is in a state of *equilibrium*. This means that the object is either at *rest* or moving at a *constant velocity*. *It cannot be accelerating.*

*What determines an object's motion?
Why, the value of the net force of course!*

$$\text{Equilibrium : } \vec{F}_{\text{net}} = 0\text{N}$$

object at rest

object moving at
constant velocity

If the net force does not equal zero, the object will accelerate at a constant rate!

NOTE

The object will accelerate in the direction of the net force.

Free-Body Diagrams

"Physics is all about simplification."

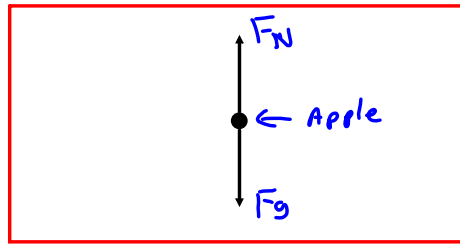
A *free-body diagram* (FBD) is a picture that shows ALL the forces acting on an object.

For the sake of simplicity, an object is usually represented by a dot and only the forces acting on the object are included on the diagram. The forces are represented by arrows.

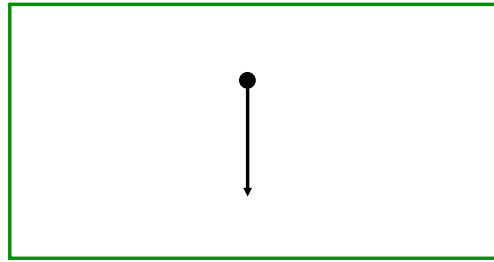
When drawing FBDs, put the tail of the force vectors on the object, with the arrow pointing away from the object. NEVER draw a force vector pointing toward an object.

Examples:

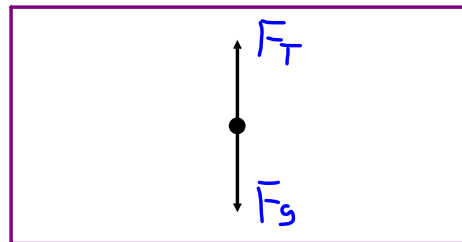
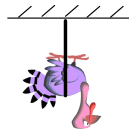
An *apple* rests on a desk.



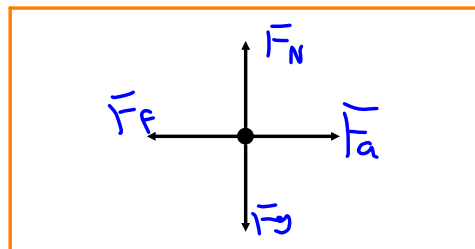
A *flower pot* falls in the absence of air resistance.



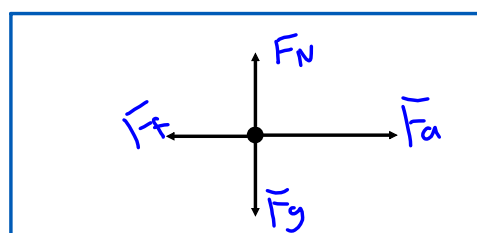
A *turkey* is hung from the ceiling of a classroom.



A snail pushes a *pumpkin* across the floor at constant ~~speed~~ *velocity*.



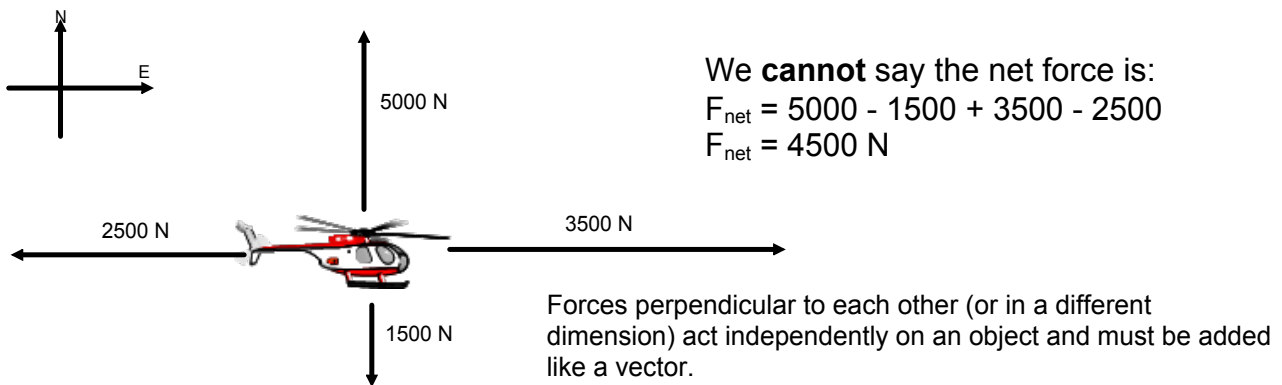
A *car* speeds up while traveling on a dirt road.



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 can talk about the net force in each dimension:

$$F_{\text{net}} [\text{East}] = 3500 \text{ N} - 2500 \text{ N}$$

$$F_{\text{net}} [\text{E}] = 1000 \text{ N}$$

$$F_{\text{net}} [\text{North}] = 5000 \text{ N} - 1500 \text{ N}$$

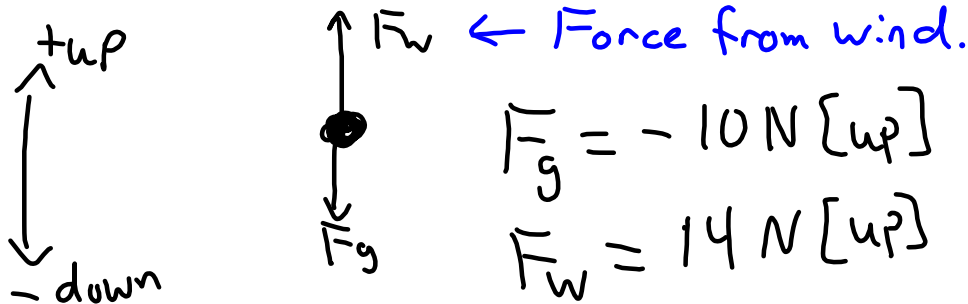
$$F_{\text{net}} [\text{N}] = 3500 \text{ N}$$

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.

Solving Problems with Common Forces

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



$$\vec{F}_{net} = \sum \text{Forces}$$

Capital Sigma (means "Sum of")

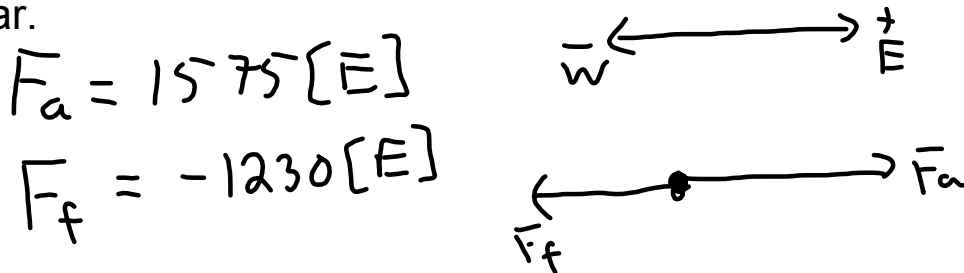
$$\vec{F}_{net} = \vec{F}_g + \vec{F}_w$$

* Check if all same dimension

$$= -10 + 14$$

$$= 4 \text{ N}$$

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



$$\begin{aligned} \vec{F}_{net} &= \sum \text{Forces} \\ &= F_a + F_f \\ &= 1575 + (-1230) \end{aligned}$$

$$\vec{F}_{net} = 345 \text{ N}$$

The net horizontal force acting on a crate is 25 N. If the applied force is 135 N calculate the force of friction.

$$\vec{F}_{net} = 25 \text{ N [right]} \quad \begin{array}{c} \leftarrow \text{left} \quad \rightarrow \text{right} \end{array}$$

$$\vec{F}_a = 135 \text{ N [right]}$$

$$F_f = ?$$

$$\vec{F}_{net} = \sum \text{ Forces}$$

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

$$25 = 135 + F_f$$

$$25 - 135 = 135 + F_f - 135$$

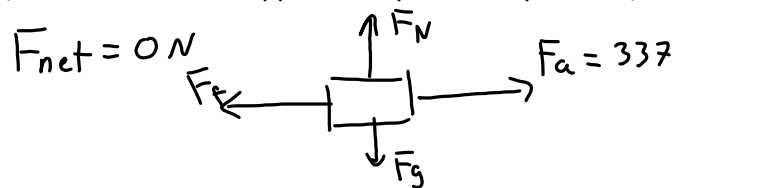
$$\boxed{-110 = F_f}$$

A 62 kg crate is pulled at a constant velocity with an applied force of 337 N. $F_{net} = 0$

a. Calculate the force of friction.

b. Calculate the normal force on the crate.

c. Calculate the coefficient of kinetic friction.



$$a) F_f = ? \quad F_{net} = \sum \vec{F}_{forces}$$

$$F_{net} = \vec{F}_a + \vec{F}_f$$

$$0 = 337 + F_f$$

$$\boxed{-337 N = F_f}$$

$$b) F_N = ?$$

$$F_{net} = \sum \text{upward forces}$$

$$0 = F_g + F_N \quad * F_g = mg$$

$$0 = \underbrace{(62)(9.81)}_{\text{down}} + F_N$$

$$0 = -608 + F_N$$

$$\boxed{608 N = F_N}$$

$$c) \underline{F_f} = \mu_k \underline{F_N}$$

only use magnitudes

$$337 = \mu_k (608)$$

$$\frac{337}{608} = \mu_k$$

$$\boxed{0.55 = \mu_k}$$

Attachments

forces-and-motion-basics_all.jar

forces-1d_all.jar

friction_en.jar