Newton's 2nd Law of Motion

FORCE Causes Acceleration

Recall that ACCELERATION is the rate at which velocity changes:

1. How quickly an object *speeds up*.
2. How quickly an object *slows down*.
3. How quickly an object *changes direction*.

What is a FORCE?

Any “push” or “pull” that tend to change the state of motion of an object.

Experiments show:

Acceleration is *directly proportional* to (net) force.

MASS Resists Acceleration

What is a MASS?

- A quantitative measure of an objects inertia.
- The amount of matter or “stuff” that an object contains.

Experiments show:

Acceleration is *inversely proportional* to mass.

For example:

Three time the mass gives one-third the acceleration and

half the mass gives twice the acceleration (for the same net force).

Newton's 2nd Law of Motion

Combining these results,
we arrive at Newton's 2nd law of motion:

$$\vec{a} = \frac{\vec{F}_{net}}{m} \quad \text{or} \quad \vec{F}_{net} = m\vec{a}$$

Sometimes $\vec{F}_{net}$ is written as $\sum \vec{F}$,
where the symbol "Σ" means "the sum of…"

Example 1

A 10 kg box is pushed by a horizontal force of 20 N across a floor a flat floor at a constant speed. What is the force of friction between the floor and the box?

Since the speed is constant, the acceleration must be zero. Therefore, the net force on the box must be zero. The opposing force of friction must then be 20 N (in a direction opposite to the push).

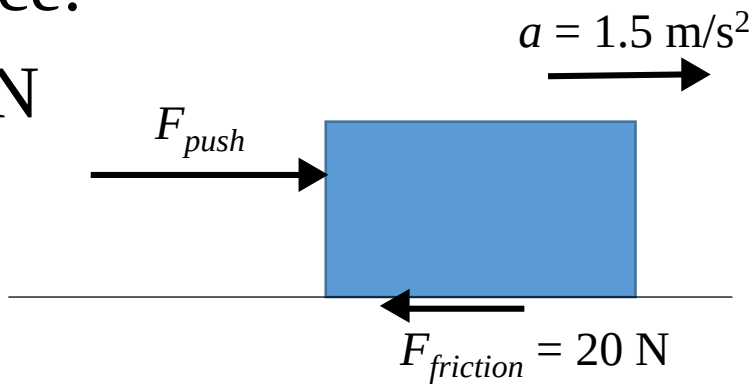
Example 2

Assuming the same frictional force between the floor and the box described in the previous question, what horizontal pushing force will give the box an acceleration of 1.5 m/s^2?

Since the box accelerates, there must be a net force:

$F_{net} = ma = (10\text{ kg})(1.5\text{ m/s}^2) = 15\text{ kg·m/s2} = 15\text{ N}$

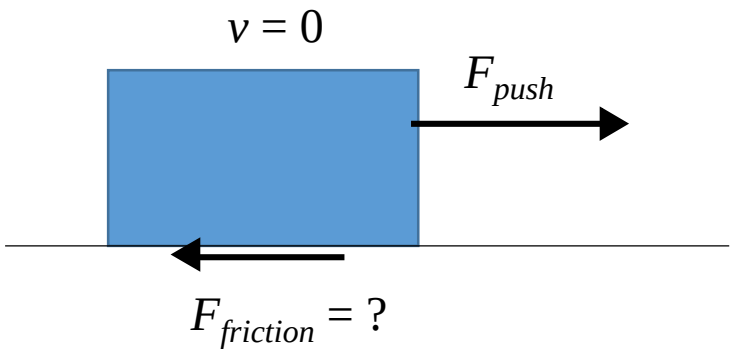
where $F_{net} = F_{push} - F_{friction}$.



Therefore, $F_{push} = F_{net} + F_{friction} = 15\text{ N} + 20\text{ N} = 35\text{ N}$

Question

You are trying to pull a heavy crate across a horizontal floor, however, your pull is not enough to get the crate to move. The force of friction opposing your push must be…



MASS versus WEIGHT

What is a WEIGHT?

For now, weight is a measure of the force of gravity on an object.

(This definition will be refined later.)

Weight = $F_{gravity} = mg$,

where g is the "acceleration due to gravity."

Near the surface of the Earth, g = 9.8m/s^2 $\approx$10 m/s^2.