Newton's Second Law

WHAT IS NEWTON'S SECOND LAW?

Newton's second law explains how the velocity of an object changes when it is subjected to an external force

The law defines a force to be equal to a change in momentum (mass times velocity) per change in time.

$$\sum F = m\,a$$

where F is the external force, m is the mass of the object, and a is the acceleration.

TYPES OF FORCES

Gravity Force $\overrightarrow{F_G}$:

For objects near the surface of earth, a force of gravity is applied to an object with mass, m. The force is

$$\overrightarrow{F_G} = m\,g;$$

where g is the free-fall acceleration which is equal to $9.8\ m/s^2$.

Tension Force $\vec{T}$:

Tension is a force generated in a rope or string. The tension force is always along the rope or string, while the magnitude of the force depends on the situation.

Spring Force $\overrightarrow{F_{sp}}$:

Spring force is exerted by a spring as it stretches or compresses. The spring force is calculated using Hooke's law:

$$\overrightarrow{F_{sp}} = -k\,\Delta\vec{r},$$

where k is the spring constant, and r is the spring displacement.

Normal Force $\vec{n}$:

Normal force is developed due to surface contact. The normal force is always perpendicular to the surface. The magnitude of the normal force depends on the situation.

Friction forces $\overrightarrow{F_s}, \overrightarrow{F_k}$:

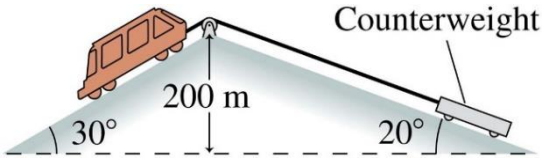
Friction force is separated into *static* and *kinetic* frictions.

Static friction ~~force~~ keeps an object from slipping on a surface. Static friction acts parallel to the surface and opposite to the direction of motion.

Kinetic friction is developed when an object slides on a surface. Similar to static friction, kinetic friction acts parallel to the surface and opposite to the direction of motion.

SAMPLE PROBLEMS

1) A 2000 kg cable car, shown in the figure, descends a 200-m high hill. In addition to its brakes, the cable car controls its speed by pulling an 1800 kg counterweight up the other side of the hill. The rolling friction of both the cable car and the counterweight are negligible.



   a) How much braking force does the cable car need to descend at a constant speed?

   b) One day, the brakes fail just as the cable car leaves the peak on its downward journey. What is the runaway car's speed at the bottom of the hill?

2) The coefficient of static friction is 0.6 between the two blocks in the figure below. The coefficient of kinetic friction between the lower block and the floor is 0.20. Force *F* causes both blocks to cross a distance of 5.0 m, starting from rest. What is the least amount of time in which this motion can be completed without the top block sliding on the lower block?