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# Newton's First Law

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Honors Physics

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# Facts about Force

- Unit is the **NEWTON(N)**
  - Is by definition a push or a pull
  - Can exist during physical contact (Tension, Friction, Applied Force)
  - Can exist with NO physical contact, called **FIELD FORCES** ( gravitational, electric, etc)
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## Newton's First Law – The Law of Inertia

**INERTIA** – a quantity of matter, also called **MASS**.  
Italian for “LAZY”. Unit for MASS = **kilogram**.

**Weight** or Force due to Gravity is how your MASS is effected by gravity.

$$W = mg$$

**NOTE:** MASS and WEIGHT are NOT the same thing. MASS never changes  
When an object moves to a different planet.

What is the weight of an 85.3-kg person on earth? On Mars ( $g=3.2 \text{ m/s/s}$ )?

$$W = mg \rightarrow W = (85.3)(9.8) = 835.94N$$

$$W_{MARS} = (85.3)(3.2) = 272.96N$$

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## Newton's First Law

*An object in motion remains in motion in a straight line and at a constant speed **OR** an object at rest remains at rest, **UNLESS** acted upon by an **EXTERNAL (unbalanced) Force**.*

There are **TWO** conditions here and one constraint.

**Condition #1** - The object CAN move but must be at a **CONSTANT SPEED**

**Condition #2** - The object is at **REST**

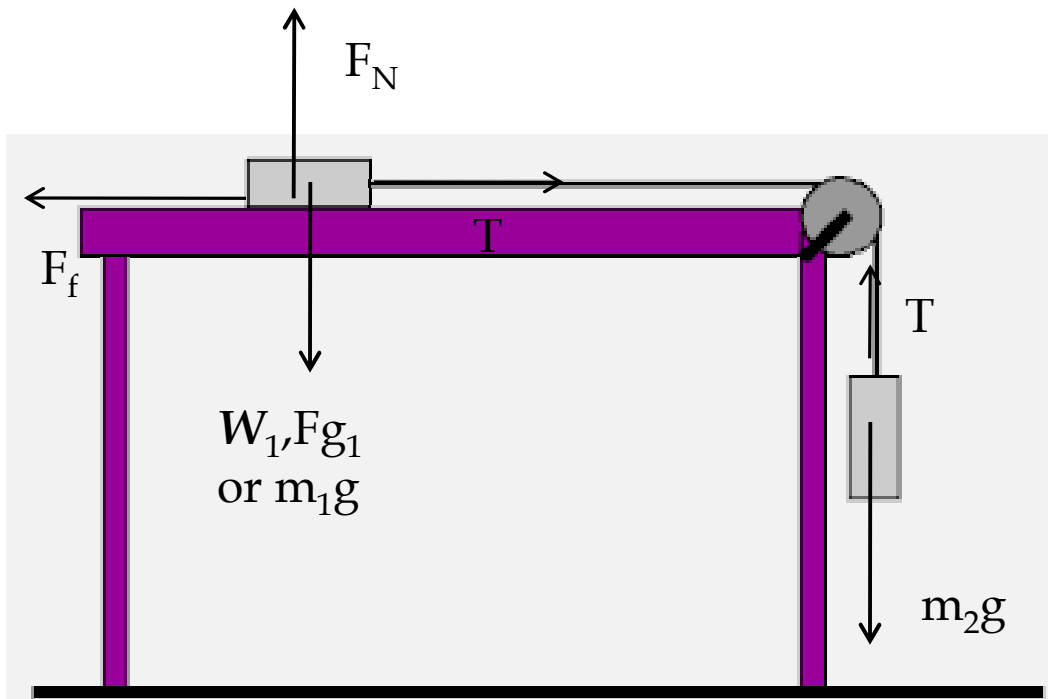
**Constraint** - As long as the forces are **BALANCED!!!!** And if all the forces are balanced the **SUM** of all the forces is **ZERO**.

**The bottom line:** There is **NO ACCELERATION** in this case **AND** the object must be at **EQUILIBRIUM** ( All the forces cancel out).

$$acc = 0 \rightarrow \sum F = 0$$

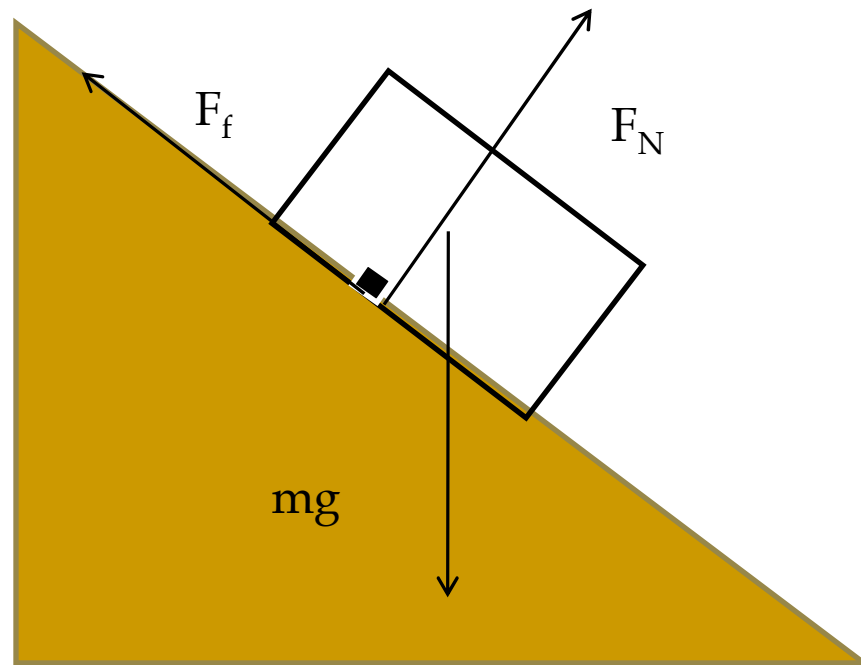
# Free Body Diagrams

A pictorial representation of forces complete with labels.



- **Weight ( $mg$ )** - Always drawn from the center, straight down
- **Force Normal ( $F_N$ )** - A surface force always drawn perpendicular to a surface.
- **Tension ( $T$  or  $F_T$ )** - force in ropes and always drawn AWAY from object.
- **Friction ( $F_f$ )** - Always drawn opposing the motion.

# Free Body Diagrams



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## Newton's First Law – The Law of “EQUILIBRIUM”

Since the  $F_{\text{net}} = 0$ , a system moving at a constant speed or at rest MUST be at “EQUILIBRIUM”.

### TIPS for solving problems

- Draw a FBD
  - Resolve anything into COMPONENTS
  - Write equations of equilibrium
  - Solve for unknowns
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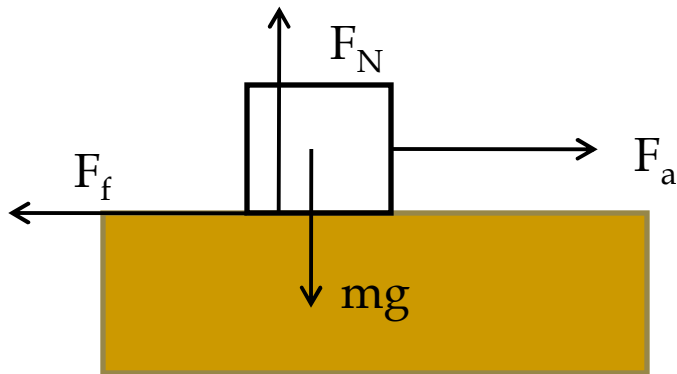
# Example

A 10-kg box is being pulled across the table to the right at a constant speed with a force of 50N.

a) Calculate the Force of Friction  $F_a = F_f = 50N$

a) Calculate the Force Normal

$$mg = F_n = (10)(9.8) = 98N$$





# Example

Suppose the same box is now pulled at an angle of 30 degrees above the horizontal.

a) Calculate the Force of Friction

$$F_{ax} = F_a \cos \theta = 50 \cos 30 = 43.3N$$

$$F_f = F_{ax} = 43.3N$$

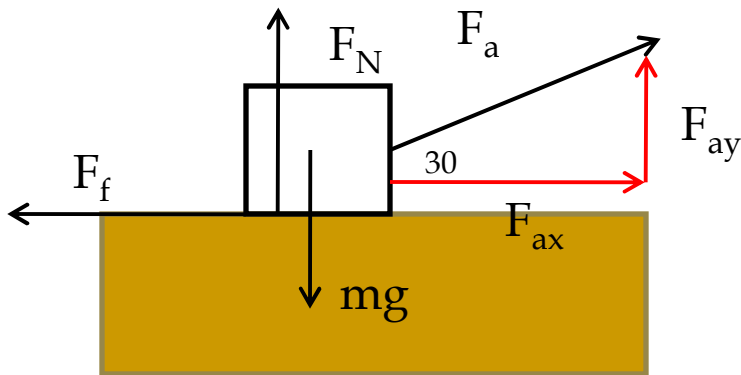
a) Calculate the Force Normal

$$F_N \neq mg!$$

$$F_N + F_{ay} = mg$$

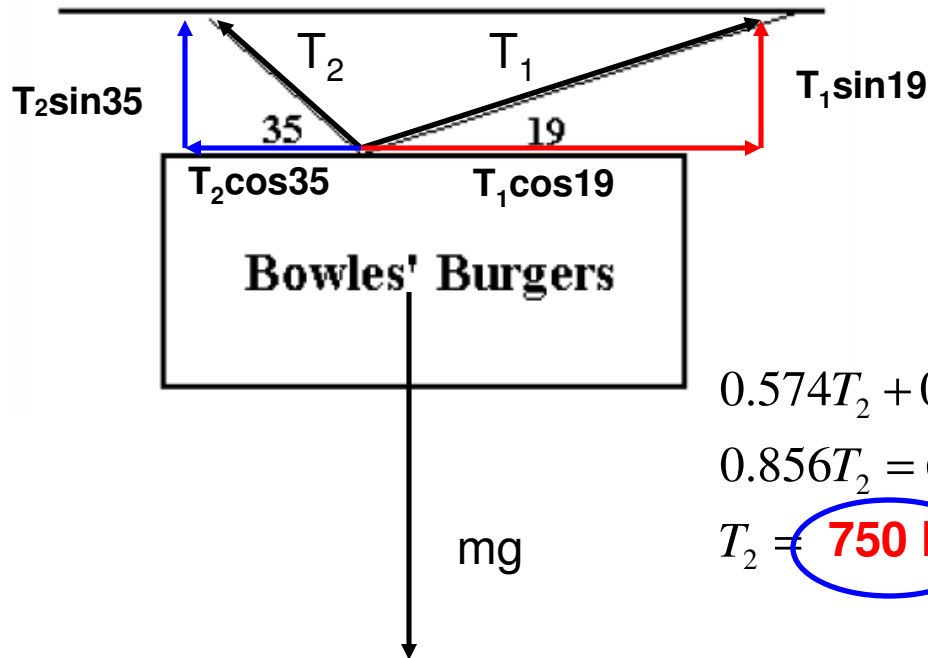
$$F_N = mg - F_{ay} \rightarrow (10)(9.8) - 50 \sin 30$$

$$F_N = 73N$$



# Example

A cafe sign with a mass of 65.5 kg is being held up by 2 cables as shown in the picture to the left. Calculate the tension in each of the ropes.



*X - Direction*

$$T_2 \cos 35 = T_1 \cos 19$$

$$T_1 = 0.866T_2$$

$$T_2 \sin 35 + T_1 \sin 19 = mg$$

$$0.574T_2 + 0.326T_1 = 642$$

$$0.574T_2 + 0.282T_2 = 642$$

$$0.856T_2 = 642$$

$$T_2 = 750 \text{ N}$$

$$T_1 = 650 \text{ N}$$