Some Particular Forces

- The Gravitational Force
- Weight
- The Normal Force
- Friction
- Tension

(1) The Gravitational Force

“A gravitational force $F_g$ on a body is a certain type of pull that is directed toward a second body.”

In our case, we consider Earth the second body.

When we speak of the gravitational force $F_g$ on a body, we usually mean a force that pulls on it directly toward the center of Earth.

Example: (i) Free Fall

\[ F_{net} = ma \]

\[ -F_g = -mg \]
\[ F_g = mg \]

"The magnitude of the gravitational force is equal to the mg."

(ii) **At least**: The same $F_g$ acts on the body when it is at least.

For the gravitational force to disappear, Earth would have to disappear.

\[ \bar{F}_g = -F_g \hat{j} = -mg \hat{j} = +mg \]

\[ \bar{F}_g = mg \hat{j} \]
2) Weight

"The weight \( W \) of a body is the magnitude of the net force required to prevent the body from falling freely, as measured by someone on the ground."

Mathematically,

\[ W = F_g \]

Example: Freely falling apple of mass \( m \).

\[ F_{\text{net}} = ma \Rightarrow F_{\text{net},y} = ma_y \]

\[ -F_g = -W = -mg \]

\[ \Rightarrow F_g = W = mg \]

(mass-weight relationship)

How to measure weight?

→ Use a balance to find its mass then compute its weight
→ Use a spring balance scale that measures weight on a calibrated scale.
Note: Weight **MUST** be measured when the body is not accelerating vertically. (e.g., not in an elevator)

3) The Normal Force

If you are standing on a surface, the push back on you from the surface (due to deformation) is the **normal force** ($F_n$).

→ **Perpendicular force** (to the surface)

* Only **ideal** rigid body don't deform.

Example

![Diagram of a block with forces](image)
Applying Newton's 2nd Law:

\[ F_{net} = m \ddot{a} \Rightarrow F_N - F_g = m \ddot{a} \]
\[ F_N - mg = m \ddot{a} \]

\[ F_N = m(g + \ddot{a}) \]

Ay: Vertical acceleration of the table & block.

If the table & block are not accelerating relative to the acceleration then \( \ddot{a} = 0 \)

\[ F_N = mg \]

4) The Frictional Force

\[ \text{Occurs when one object slides or attempt to slide over another.} \]
\[ \text{Directed along the surface but opposite to the direction of intended motion.} \]
5) **Tension Force**

“Force in a **Cord**” → massless (compared to body) and unstretchable.

→ When a cord is attached to a body and pulled taut (tightly), the cord pulls on the body with a force $\mathbf{T}$ directed away from the body and along the cord. This force is often called a tension force.

→ The tension in the cord is the magnitude $T$ of the force on the body.

*Diagrams showing tension forces at both ends of the cord.*
Example. The suspended body weighs 75 N. 98 T equal to, greater than, or less than 75 N when the body is moving upward at:

a) Constant Speed
b) Decreasing Speed
c) Increasing Speed.

\[ T - mg = ma_y \]

\[ F_{net} = ma_y \]

\[ F_g = W = mg \]

\[ T = m(g + ay) \]

a) \( ay = 0 \Rightarrow T = mg = W = 75 \text{ N} \Rightarrow \text{equal to} 78 \text{ N} \]

b) \( ay \) would be lesser \( \Rightarrow \) less than 75 N

c) \( ay \) would be greater \( \Rightarrow \) greater than 75 N.