Part I: Newton’s Laws
Chapter 5: Force and Motion

5.1 Force
5.2 A Short Catalog of Forces
5.3 Identifying Forces
Forces. What are they?

What is a force?
The fundamental concept of **mechanics** is **force**.
- A force is a **push** or a **pull**.
- A force acts on an object.
- A force requires an **agent**.
- A force is a **vector**.

---

1**Heads up:** $\vec{F}_{\text{net}}$ is not a **PHYSICAL** force. It is an abstract construction. And while we are at it: “$m\vec{a}$” is not a force at all! It is literally just mass “$m$” times acceleration vector “$\vec{a}$”.

---

PHYSICAL
Every PHYSICAL force has an agent.²

²Don’t overplay any one agent: every physical force on an object has an agent. Many agents!
On our PHYSICAL forces list:

- Gravitational force, $\vec{F}_G$. 

The gravitational force pulls the box down.

$\vec{F}_G$ 

Ground
On our PHYSICAL forces list:

- Gravitational force, $\vec{F}_G$.
- Spring force, $\vec{F}_{Spring}$.
On our PHYSICAL forces list:

- Gravitational force, $\vec{F}_G$.
- Spring force, $\vec{F}_{Spring}$.
- Tension force, $\vec{T}$.

The rope exerts a tension force on the sled.
On our physical forces list:

- Gravitational force, $\vec{F}_G$.
- Spring force, $\vec{F}_{\text{Spring}}$.
- Tension force, $\vec{T}$.
- Normal force, $\vec{n}$.

The compressed molecular bonds push upward on the object.
On our *PHYSICAL* forces list:

- Gravitational force, $\vec{F}_G$.
- Spring force, $\vec{F}_{\text{Spring}}$.
- Tension force, $\vec{T}$.
- Normal force, $\vec{n}$.
- Kinetic friction, $\vec{f}_{\text{kinetic}}$.
  → Relative motion between surfaces in contact.
- Static friction, $\vec{f}_{\text{static}}$.
  → Direction? Imagine a frictionless interface.
On our **PHYSICAL** forces list:

- Gravitational force, \( \vec{F}_G \).
- Spring force, \( \vec{F}_{Spring} \).
- Tension force, \( \vec{T} \).
- Normal force, \( \vec{n} \).
- Kinetic friction, \( \vec{f}_{\text{kinetic}} \).
- Static friction, \( \vec{f}_{\text{static}} \).
- Drag force, \( \vec{F}_{\text{drag}} \).
On our \textit{physical} forces list:

- Gravitational force, $\vec{F}_G$.
- Spring force, $\vec{F}_{\text{Spring}}$.
- Tension force, $\vec{T}$.
- Normal force, $\vec{n}$.
- Kinetic friction, $\vec{f}_{\text{kinetic}}$.
- Static friction, $\vec{f}_{\text{static}}$.
- Drag force, $\vec{F}_{\text{drag}}$.
- Thrust force, $\vec{F}_{\text{thrust}}$.
- $\vec{F}_{\text{applied}}, \vec{F}_{\text{push}}, \vec{F}_{\text{pull}}$.\footnote{As in “pull on the handle”. If by means of a rope, you’re logging $\vec{T}$ as the contact force on the object.}
How do we show forces?

Forces can be displayed on a free-body diagram. You’ll draw all forces—both pushes and pulls—as vectors with their tails on the particle. A well-drawn free-body diagram is an essential step in solving problems, as you’ll see in the next chapter.

- Notice that $\vec{F}_{\text{net}}$ is not starting on the dot. It’s not part of the FBD.
- Reserve the dot for PHYSICAL forces only!
**For you to do:** A block sits at rest on a frictionless inclined plane. The block is held in place by a rope that runs parallel to the inclined plane.

Create and refine a FBD for this block following these guidelines:

- Use tilted axes with the $x$-axis running parallel to the inclined plane.
- All and only *physical* forces are logged starting on your dot.
- Do not use arrows on your axes. Label only the positive side with just an $x$ or $y$.
- Label all of your force vectors, including the vector symbol.
- Adjust the relative lengths of your force vectors so that their vector sum is 0. Just work with the *FBD*. “See” components in your mind to help.\(^4\)

\(^4\)You might consider lightly drawing in the right triangle that hints at the decomposition of $\vec{F}_G$, but your full physical forces should always stick out boldly, much more so than any optional additions.