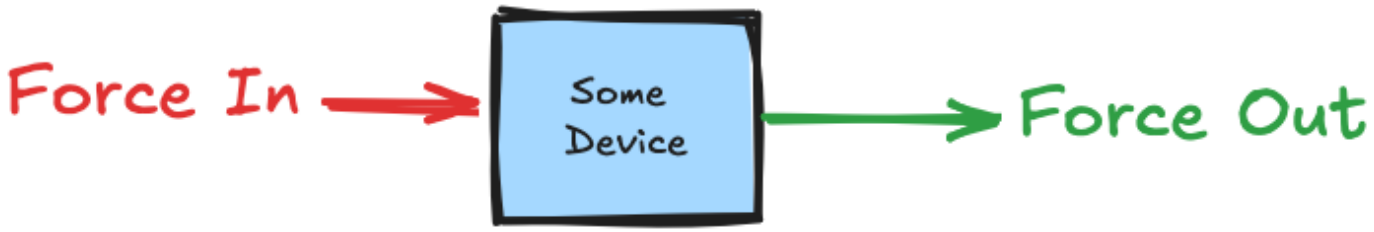
Mechanical Advantage

Mechanical advantage is a measure of the force **amplification** achieved by using a tool, mechanical device or machine system. This is calculated as the ratio between the input force, and the output force of the device/tool.



$$\text{Mechanical Advantage} = \frac{\text{Force Out}}{\text{Force In}}$$

> For example, "Some Device" that is able to turn a **10 N input force** into a **20 N output force** is said to have a mechanical advantage of **2**.

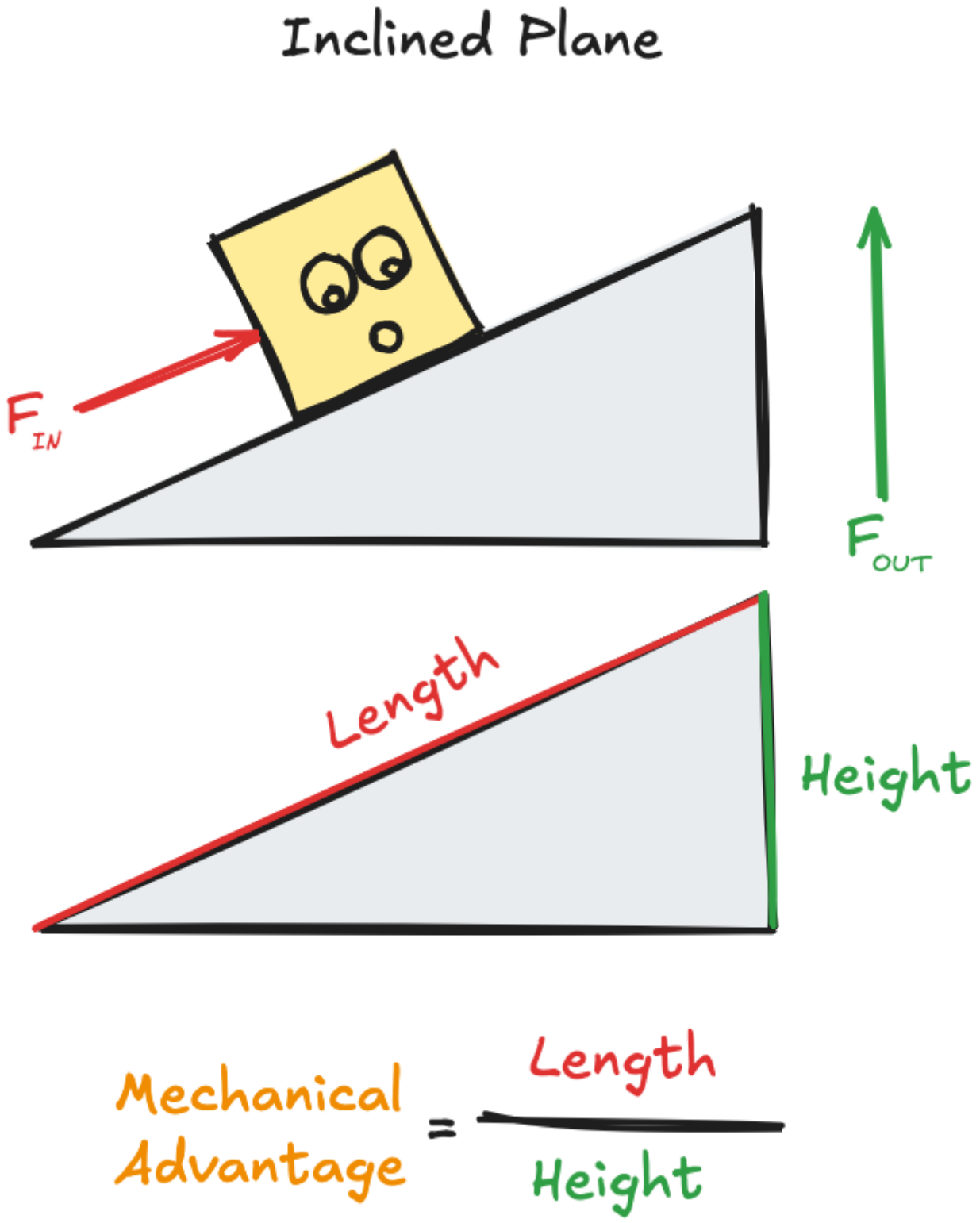
> **NOTE**: Because **mechanical advantage** is a **ratio**, **it does not have a unit**.

Simple Machines

Typically, we will achieve mechanical advantage by employing **simple machines**. A **simple machine** is a mechanical device that changes the direction and/or magnitude of a force and come in a few varieties.

Inclined Plane

An **inclined plane**, also known as a ramp, is a flat supporting surface tilted at an angle from the vertical direction, with one end higher than the other, used as an aid for raising or lowering a load.



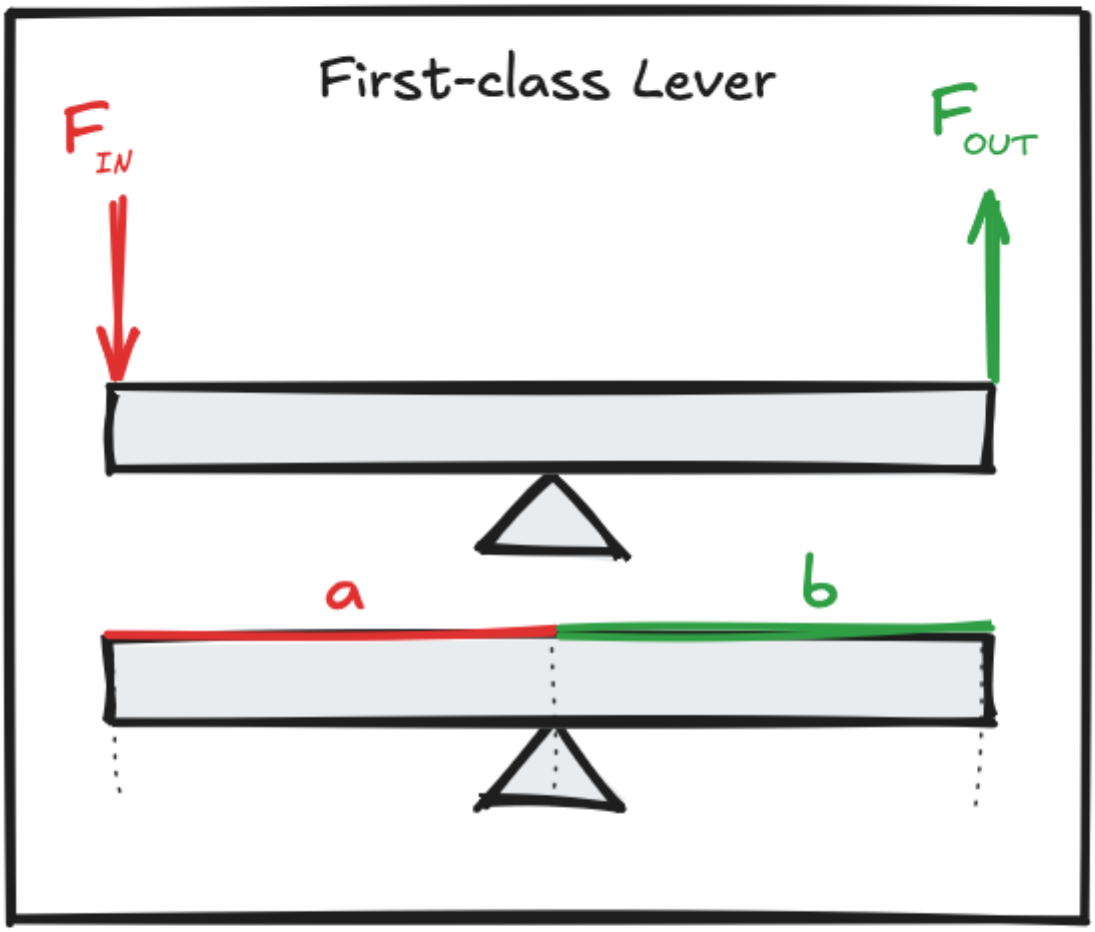
> **Examples**: Ramps, slides, roofs

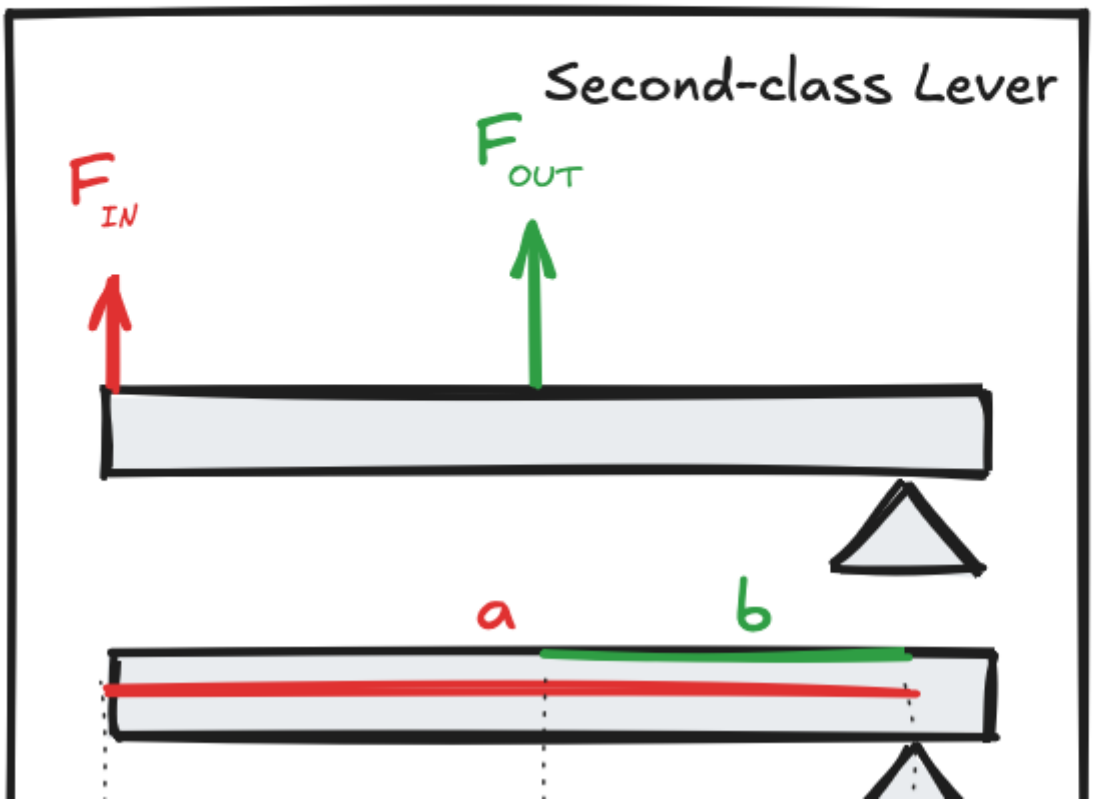
Levers

A **lever** is a simple machine consisting of a beam or rigid rod pivoted at a fixed hinge, or **fulcrum**. Levers are then classified by the relative positions of the fulcrum, input, and output forces.

Levers

Mechanical Advantage = $\frac{a}{b}$ = Fulcrum

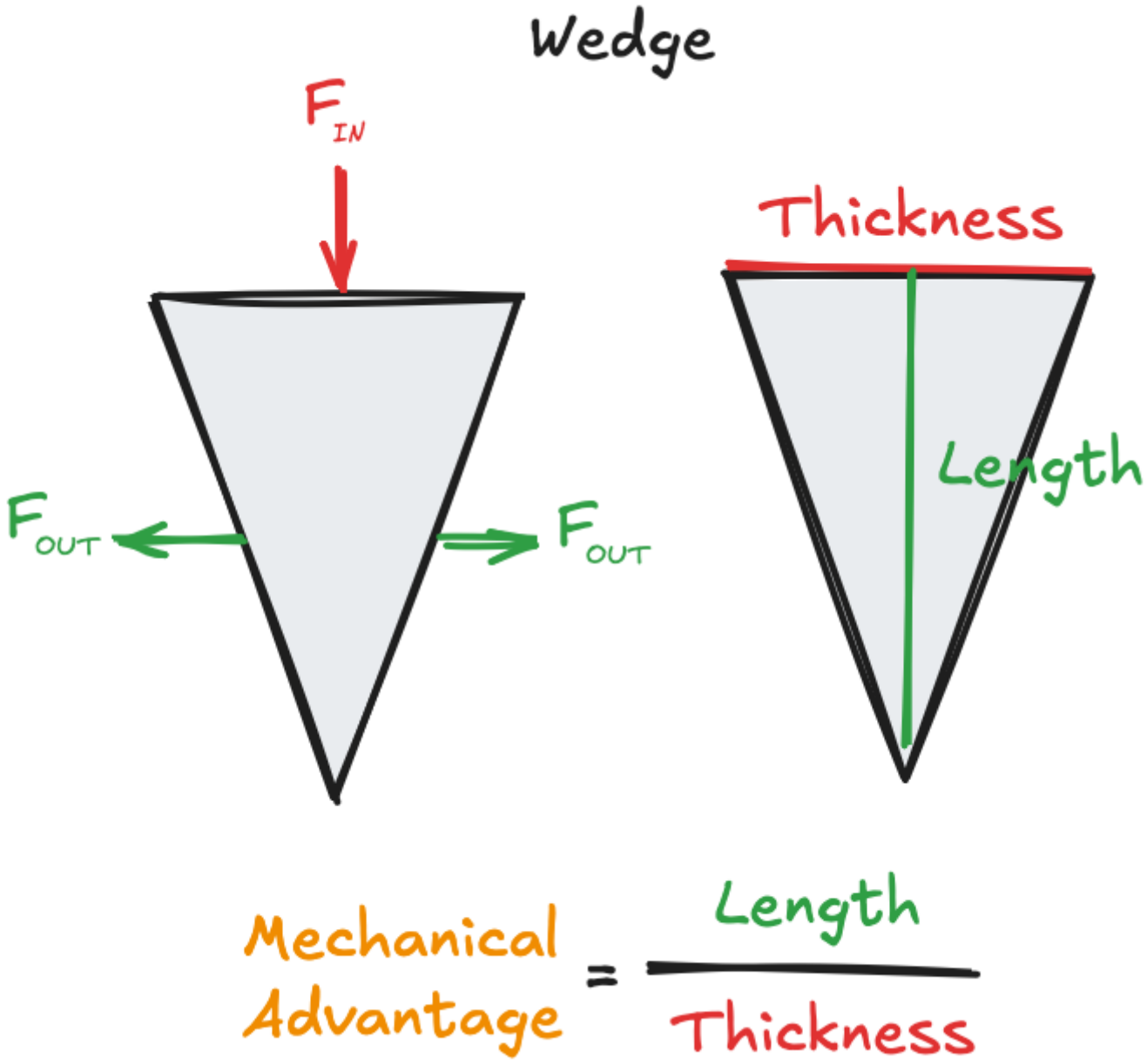




> **Examples**: See-saws (first-class), wheelbarrows (second-class), fishing rod (third-class)

Wedge

A **wedge** is a **triangular** shaped tool that is typically used to separate two objects or portions of an object. It can also be used to hold objects in place, and resembles a **portable inclined plane**.

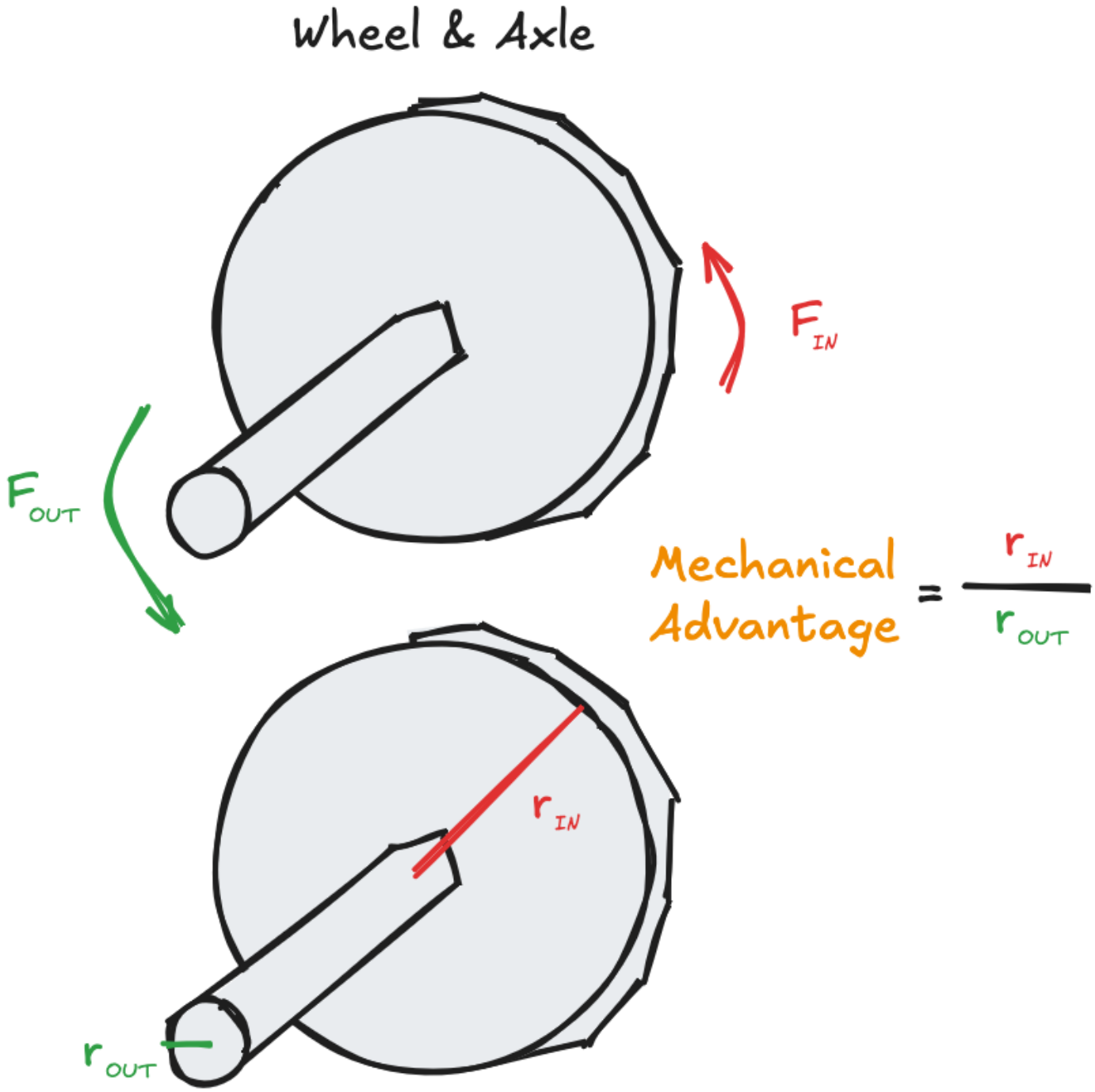


> **Examples**: Axes, door-stoppers, knives

Wheel & Axle

The **wheel and axle** is a simple machine, consisting of a **wheel** attached to a smaller **axle** so that these two parts rotate together, in which a force is transferred from one to the other. The **wheel**

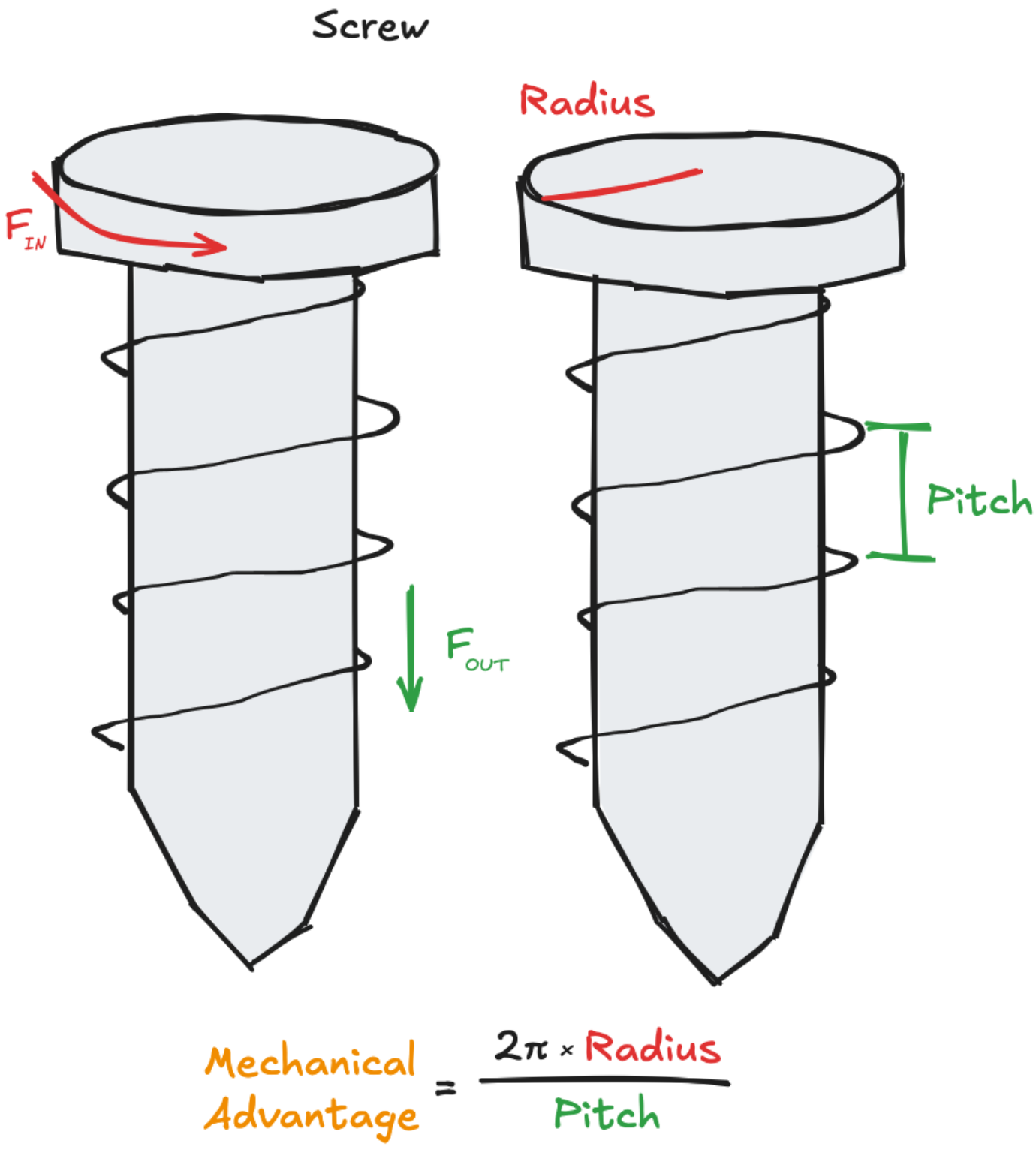
and axle can be viewed as a version of the **lever**, with a drive force applied tangentially to the perimeter of the wheel, and a load force applied to the axle supported in a bearing, which serves as a **fulcrum**.



Screw

The **screw** is a simple machine that converts **rotational motion** to **linear motion**, and a torque (rotational force) to a linear force. The amount of mechanical advantage achieved by a screw depends on both the input radius, and the pitch length.

The **input radius** is considered to be the distance from where the force is applied, to the axis around which the screw spins. The pitch length is the distance between each threads of the screw, or how long the screw has moved after one rotation.



Other Types of Machines

Up until this point, we have discussed simple machines which are well... simple. They are comprised of very few parts -- sometimes only one. There are also machines that, by their nature, require (at least) a few moving parts to achieve mechanical advantage.

Gears

Pulleys

Conservation of Energy

An important thing to note when dealing with simple machines

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