ZERO ROBOTICS

SPHERES ISS CHALLENGE

Force

Force

- A **force** is an interaction between two objects.
- Even though the force of gravity can be neglected in Zero Robotics, forces exist between satellites and objects.
- **Friction** is another force that is ubiquitous on Earth but not present in Zero Robotics.
- **Newton's Laws of Motion** describe the core principles of force.

Newton's First Law

- Newton's First Law is more commonly known as **The Law of Inertia**.
- An object at rest remains at rest until acted on by an outside force; an object in motion remains in motion until acted on by an outside force.
- On Earth, the outside forces that stop objects in motion are usually friction and air resistance.
- In frictionless space, your satellite will remain in motion until it fires its thrusters in the opposite direction.
- Air resistance is not considered in the simulations, but is a factor on the ISS. However, the satellites move at such low speeds that it will not drastically alter their performance.

Newton's Second Law

- Newton's Second Law is one of the most important equations in physics:

$$\mathbf{F} = m\mathbf{a}$$

Force = mass x acceleration

- Mass is a scalar quantity and acceleration is a vector. Since a scalar times a vector is a vector, force is a vector.
- To maximize acceleration, you need to maximize the force exerted on the object and minimize the mass of the object.

Newton's Third Law

- Every action has an equal and opposite counter-reaction.
- On Earth, if you exert a force of 1500 N on the ground, the ground pushes up with a **normal force** of exactly 1500 N. This keeps you in place.
- If opposing forces are unbalanced, the object will accelerate.
  - ex: If you push a box with 5 N to the right and your friend pushes the box with 10 N to the left, the box will accelerate to the left.

Controlling SPHERES

- All motion is controlled by forces. Every function you have used to control your satellite relates to force.
- When you set a position target, your thrusters fire in the opposite direction; by Newton's Third Law, the satellite accelerates toward the target.
- When you set a position, velocity, or attitude target, you are controlling forces in a **closed loop** system. This means that the satellite auto-adjusts its forces to meet your target.