ZERO ROBOTICS

SPHERES ISS CHALLENGE

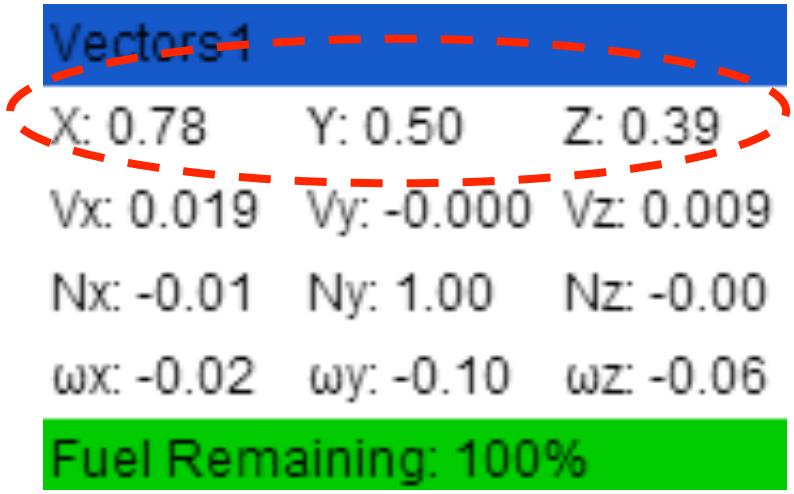
Kinematics

Kinematics

- **Kinematics** is a branch of dynamics that deals with the study of motion without considering the forces that cause the motion.
- Among other things, kinematics encompasses **position**, **speed**, **velocity**, and **acceleration.**
- This PowerPoint reviews concepts that are applied to code in later tutorials.

Position

- Position is where an object is located.
- Your satellite's position is stored in the first three elements of the state array, which we typically call **myState**.
- You can control position with the setPositionTarget function.



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Distance vs. Displacement

- **Distance** is the measure of change in position, or how far an object has moved.
- **Displacement** is the measure of how far an object's final position is from its original position.
- Displacement is a vector, but distance is a scalar.
- ex: Bill walks 4 ft to the right, 2 feet to the left, and 3 feet to the right again.
  - Bill traveled a total distance of 4+2+3 = 9 ft.
  - Bill's displacement is 4-2+3 = 5 ft to the right.

Speed

- Speed is how fast an object is moving.
- Speed is a **rate** that can be calculated by dividing how far the object moved by the time it took the object to move that far.

$$speed = distance / time$$

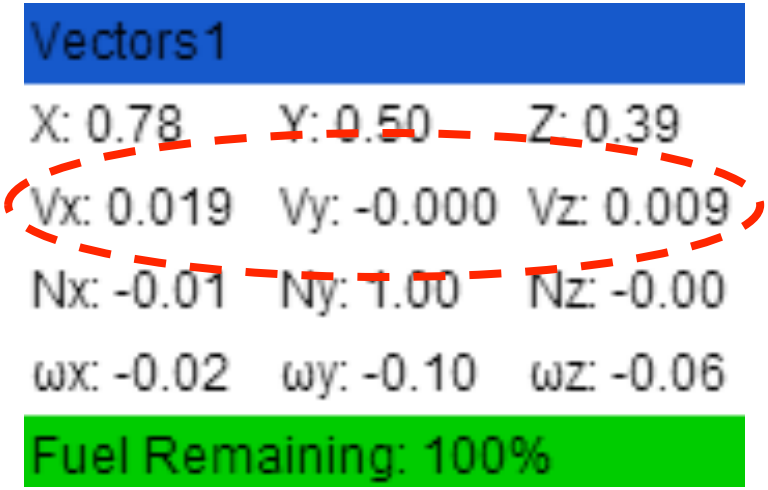
- This formula is often modified to isolate distance.

$$distance = speed * time$$

$$d = vt$$

Velocity

- The difference between velocity and speed is that velocity includes speed *and* direction.
- Velocity is a vector, but speed is a scalar.
- While speed = distance/time, you can think of velocity as displacement/time.
- The three components of velocity are stored in the fourth, fifth, and sixth elements of myState.



Acceleration

- Acceleration is how fast an object's velocity is changing.
- Acceleration is a vector, and has direction.
- To calculate acceleration, divide the change in velocity by time.

$$a = \frac{\Delta v}{t}$$

- Negative acceleration is known as **deceleration.**

Motion Equations

- On the next slide are the five essential equations of kinematics.
- v ← velocity
- a ← acceleration
- d ← displacement
- t ← time
- The subscript 0 indicates an initial value.
- A symbol without a subscript indicates a final value.

Motion Equations

$$a = \frac{v - v_0}{t}$$

$$d = \frac{v + v_0}{2} t$$

$$d = v_0 t + \frac{1}{2} a t^2$$

$$d = vt - \frac{1}{2} a t^2$$

$$v^2 - v_0^2 = 2ad$$

Linear Momentum

- **Momentum** (*p*) is an important factor in SPHERES dynamics. Momentum = mass x velocity.

$$p = mv$$

- Essentially, the faster your satellite is moving, the more momentum it will have. The more momentum it has, the harder it will be to stop or change direction.
- In some ZR games, your satellite's mass will change. Remember that an increase in mass leads to an increase in momentum.

SPHERES Dynamics

- Now that you know the basics of kinematics, you can apply these concepts to your algorithms.
- You don't have to be a master physicist to do well in Zero Robotics, but knowing how to control motion will give you a huge advantage in the competition.
- The Intermediate tutorials will teach you how to apply the concepts you just learned to your algorithms.