ZERO ROBOTICS

SPHERES ISS CHALLENGE

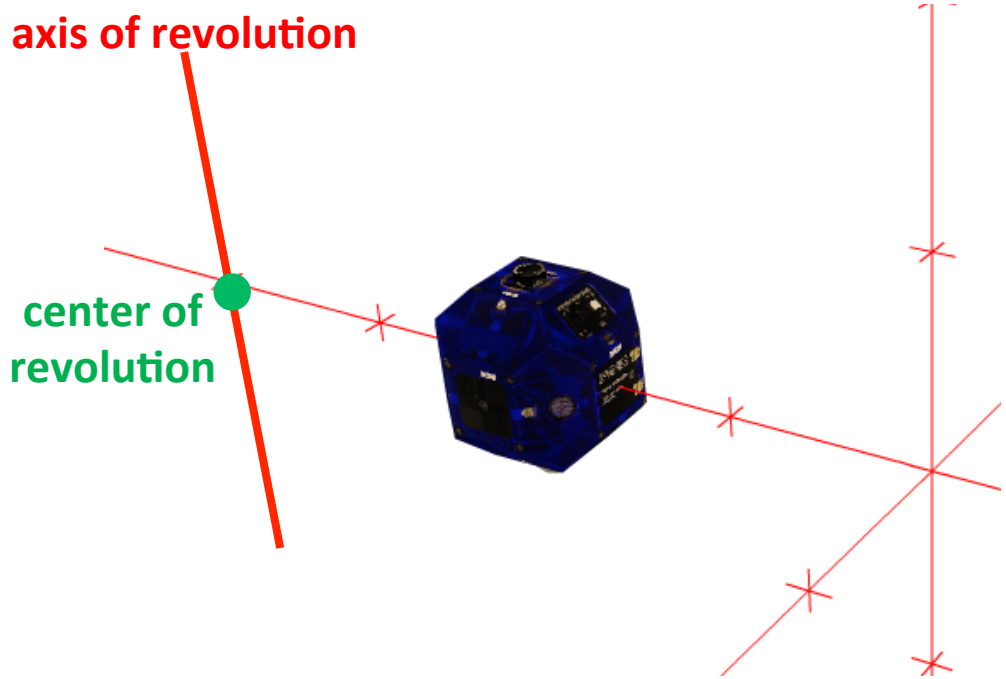
Revolving: Tilted Axis

Tilted Axis

- The polar coordinate method only works in 2-D. When the axis of revolution is tilted, the satellite needs to revolve in 3-D. To accomplish this, we will use the same method we used for spinning on a tilted axis: cross product.
- This tutorial will deal with a tilted axis at a random point that is not the origin. This is one of the most advanced tutorials, and we won't explain everything. We want you to come up with a creative solution on your own.

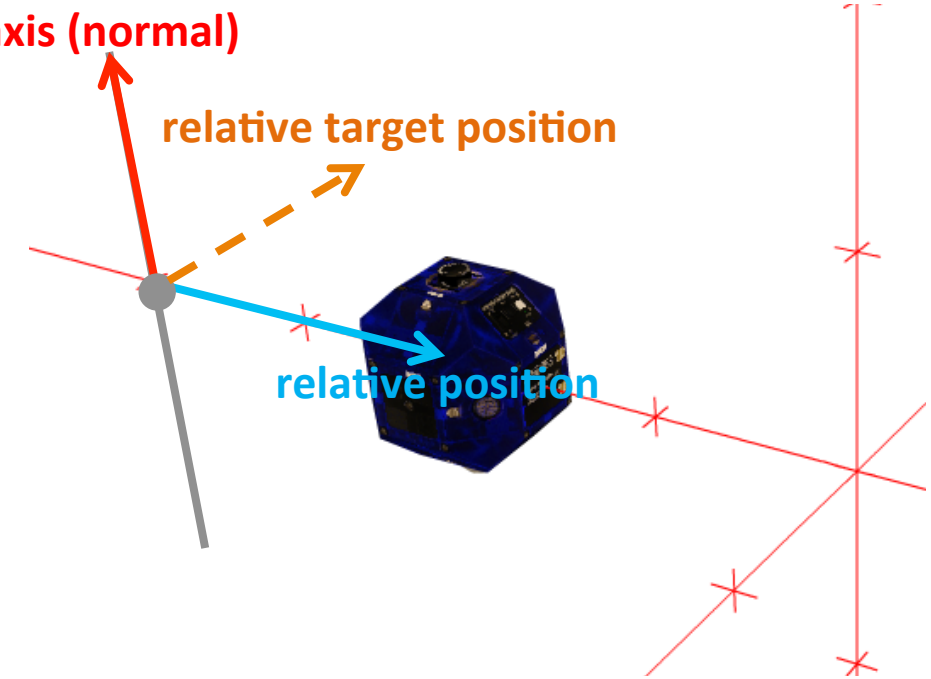
The Method

- We will walk you through the technique before we get into the code. Imagine this is our scenario:



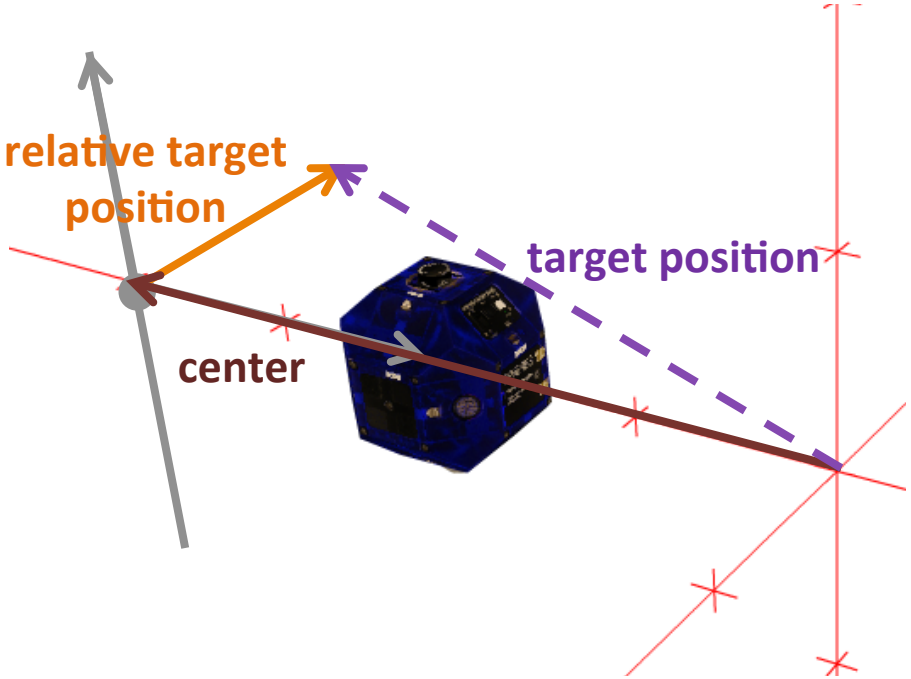
Cross Product

- Taking the cross product of the satellite's relative position and the axis will give us a target position on the plane of rotation.



Target Position

- The target position is also relative to the center. We need to make it relative to the origin. To do this, we can use vector addition.



Try It

- Let's code! Create a new project called Project21 and create the following arrays:
  - **center**
  - **axis**
  - **myState**
  - **myPos**
  - **relPos**
  - **relTargetPos**
  - **targetPos**
  - **targetAtt**
- Initialize center and axis with random values. We chose (0.2, 0.8, 0.5) for center and [0.5, 0.3, 1.0] for axis.
- In loop(), normalize axis.

SPHERES Position

- Get myState and write the position array to myPos.
- We need to find the satellite's relative position. Make relPos a vector that points from center to myPos. You can accomplish this using vector subtraction.

```
24    api.getMyZRState(myState);
25    for (int i=0; i<3; i++)
26      myPos[i]=myState[i];
27    mathVecSubtract(relPos,myPos,center,3);
```

Target Position

- Now, we can find the cross product. Crossing relPos and axis will produce a target position relative to the center. Store this in relTargetPos.
- To set a position target, we need the position vector relative to the origin. Add the vectors center and relTargetPos to find targetPos.
- Set the position target.

```
29    mathVecCross(relTargetPos,relPos,axis);
30    mathVecAdd(targetPos,center,relTargetPos,3);
31    api.setPositionTarget(targetPos);
```

Face the Center

- All that's left is to face the center. Use vector subtraction to find the vector pointing from myPos to center. Store this vector in targetAtt.
  - An alternative method is to negate the components of relPos, as relPos points from center to myPos.
- Normalize targetAtt and set the attitude target.
- Compile and run.

```
33    mathVecSubtract(targetAtt,center,myPos,3);
34    mathVecNormalize(targetAtt,3);
35    api.setAttitudeTarget(targetAtt);
36  }
```

Results

- The radius of the orbit approaches 0 so that the satellite ends up spinning at the center.
- One reason for this is that we don't give the satellite enough time to reach the target position.
- If you experiment with a counter, you'll find another reason. The cross product is dependent on the satellite's relative position, so any fluctuations in position are amplified.
  - If the satellite is too close to the center, it will approach the center. Too far from the center, and it will stray farther and farther away.

Modifications

- There are plenty of ways to optimize revolution.
- Remember uniform circular motion? Try to keep a constant radius and angular speed as you revolve. Aim to create a solution that gives you as much control over the satellite as possible.
- Like spinning, revolving is an integral part of many Zero Robotics games. Try to come up with a versatile algorithm that your team can build off of from year to year.
- As always, work as a team to find a solution. Good luck!