CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
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Project Number
36486

Project Title
Tumbling Polygons: Using Angular Momentum to Flip Polygon Robots

Abstract

Objectives/Goals
The goal of this project was to explore how polygonal robots move. Engineers have created cube robots that flip by using flywheels that spin fast and stop abruptly. My project explores beyond a simple four sided square cross-section to polygons of several sides: 5, 6, 8, 10, and 12 sides. The specific objective of this study was to determine if increasing the number of sides will decrease the torque required to rotate a polygon.

Methods/Materials
I derived an equation of motion that relates the torque required to rotate a polygon, the number of sides of the polygon and the radius of the polygon. I tested my hypothesis by creating a series of polygons of various sides, made from foam core, whose radii were based on the parameters calculated by my equation. A motor was placed at the center of the polygon. I controlled the motor through a motor driver coupled to an Arduino. The starting torque of the motor was used to rotate the polygon. I tested my equation by building and rotating polygons with a variety of sides that were larger and smaller than the predicted maximum radii that could be rotated by the motor.

Results
The results confirmed my hypothesis and equation of motion for rotating polygons. Increasing the number of sides reduced the torque required to rotate the polygon. Decreasing the radius reduced the torque required to rotate the polygon. The configurations that were rotatable and non-rotatable were very consistent with the equation of motion for rotating the polygon. Only two out of fourteen tests produced results that were inconsistent with the equation of motion.

Conclusions/Discussion
The polygonal robots with more sides were able to flip more often than the polygonal robots with the same radius and one less sides. This meant the increase in sides led to the decrease in required torque and energy to flip the polygonal robot. However, since the polygonal robots with more sides required less torque, the polygon continued to roll. Polygons with more than four sides require less torque to flip which is advantageous. The ability to control these polygons is reduced when they require torque much smaller than the torque that the motor supplies. There is an optimum number of sides and radius for the motor in which the torque and control are balanced.

Summary Statement
I created and tested various polygonal robots to prove that an increase in the number of sides led to the decrease in required torque and energy to flip a polygonal robot.

Help Received
My father explained the details of how force and torque worked but I designed, built, and performed the experiments myself.