Zero Gravity Plant Simulation

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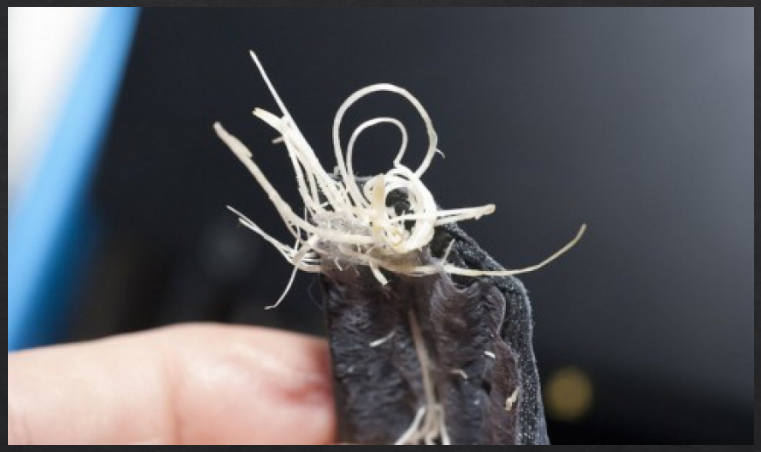
Introduction:

This project is intended to mimic plant growth in space by simulating the effects of zero gravity. The idea was to create a similar planting experience of that on a space station; where plant growth requires artificial light, would have limited water, and would have no gravitational influence.



Don Pettit's space sunflower roots. Photo by Don Pettit/NASA

Project Description:

To see if plants grew differently under the rotating conditions a control plant group was created to do a comparison. The control group was placed in the same dais and exposed to the same amount of water and light, however it was not rotated. This would allow for a root comparison to be done on the two plants. To counteract the forces of gravity and confuse the plants, they would need to have one rotation per minute and grow for a one-month period. This slow rotation would be sufficient to mimic the effects of zero gravity.

Hypothesis:

After 1 month of continuous rotation, the roots of the rotating plants will grow in various directions similar to plant growth without the influence of gravity.

Creating Continuous Rotation with an Arduino and Stepper Motor

- To rotate a heavy structure, a stepper motor was seen as the best option.
- This motor was combined with a 24V power supply, micro stepper, and Arduino Uno.
- Learned how to make code for Arduino through trial and error.
- Achieved a 1rpm continuous Rotation!
- Note: The coding for the solenoid water valve was incorporated 1 month later.

plant code - Notepad

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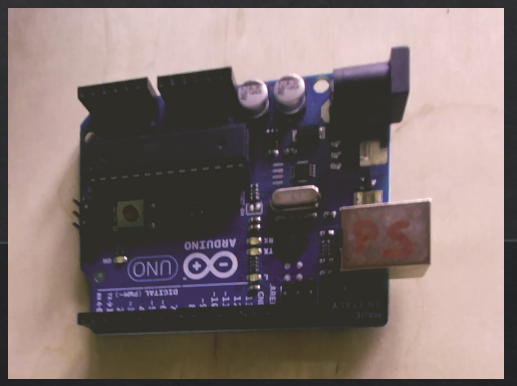
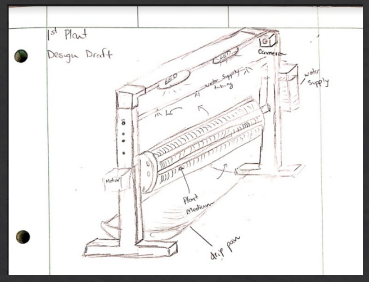
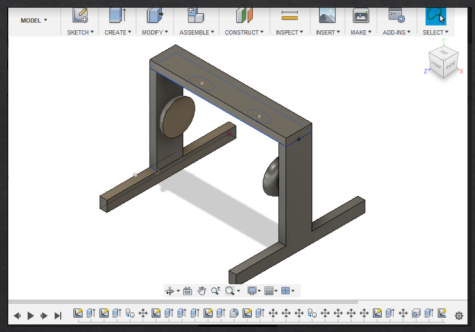
```
// STEPPER MOTOR TIMING PINS
const int stepPin = 5;
const int dirPin = 2;
const int enPin = 8;
// WATER CYCLE PINS
const int solenoidPin = 4;

// MAIN INT SETUP FOR STEPPER MOTOR AND WATER CYCLE SOLENOID
void setup() {

  // Sets the two pins as Outputs
  pinMode(stepPin,OUTPUT);
  pinMode(dirPin,OUTPUT);
  // WATER CYCLE PIN
  pinMode(solenoidPin, OUTPUT);

  pinMode(enPin,OUTPUT);
  digitalWrite(enPin,LOW);

}

// CONDITIONS FOR STEPPER MOTOR AND SOLENOID
void loop() {

  //STEPPER MOTOR
  digitalWrite(dirPin,HIGH); // Enables the motor to move in a particular direction
  digitalWrite(enPin,LOW);  // Enable rotation

  // Makes 3000 pulses for making one full cycle rotation
  for(int x = 0; x < 3050; ) {
    digitalWrite(stepPin,HIGH);
    delayMicroseconds(470);
    digitalWrite(stepPin,LOW);
    delayMicroseconds(500);

  }
   // WATER CYCLE TIMING

    digitalWrite(solenoidPin, LOW);       // Switch Solenoid OFF
    delay(86350000);                      // Wait 23 hours, 59 minutes, 45 Seconds (1000 = 1 second)
    digitalWrite(solenoidPin, HIGH);      // Switch Solenoid ON
    delay(15000);                         // Wait 15 seconds (1000 = 1 second)

  digitalWrite(enPin,HIGH);  //Disables rotation


//  delay(1000); // One second delay (uncomment if you ever need a delay and add x++ to "for(int x = 0; x < 3050;)" below)

  digitalWrite(dirPin,LOW); // Changes the rotations direction
  digitalWrite(enPin,LOW);  // Enables rotation

  // Makes 3000 pulses for making two full cycle rotation
    for(int x = 0; x < 3050;) {
    digitalWrite(stepPin,HIGH);
```

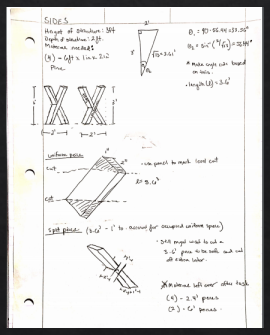


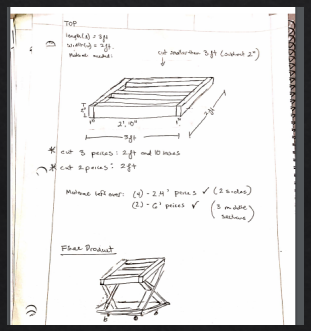
Designing the Plant Support Structure

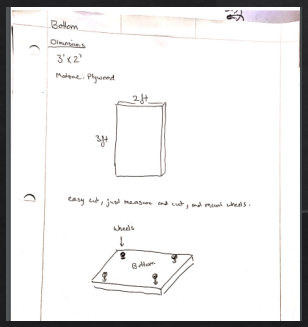
- A few drawings were hand sketched two of which became candidates for the design. After creating the first decision in CAD, another option was hand sketched and chosen instead.
- The first design didn't have enough mounting supports for the electronic parts and water supply.
- The actual project was made off of the below hand sketched design.





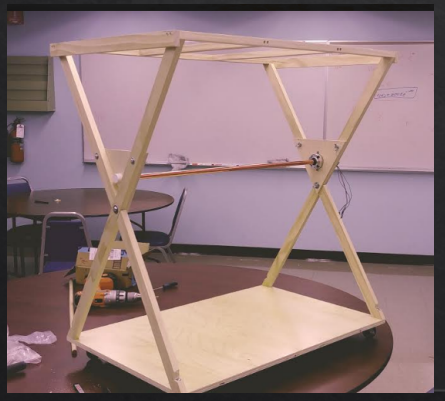






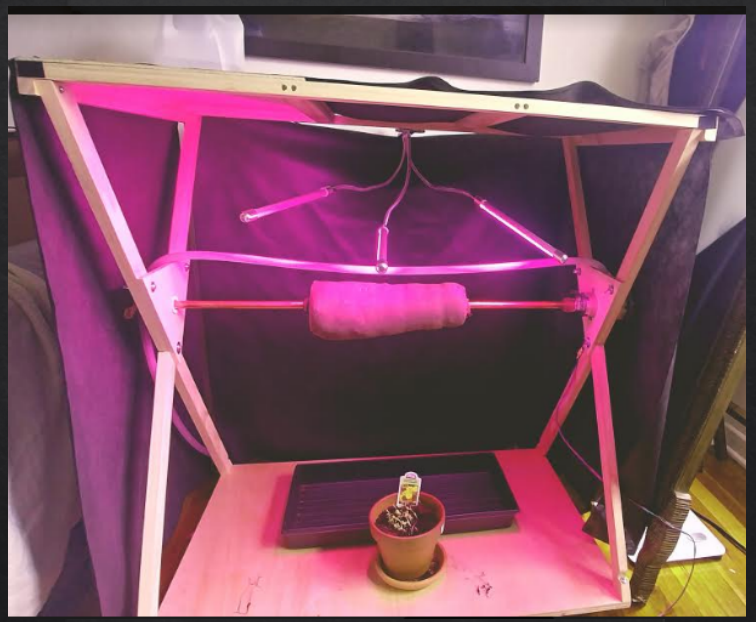
Building the Plant Support Structure

- Materials: Pine, copper tubing, silicone tubing, metal clamp, plastic tubing, nuts, bolts, screws, fabric, Velcro, wheels, plant lights, solenoid valve, electronic parts for motor and solenoid valve, water, marigold seeds.
- Design Challenges: How to best mount the stepper motor, how to keep soil around the copper tubing, how to easily take the prototype apart for transport.



Challenges and Results

- Motor was overheating, which became a fire hazard to run this continually for more than 2 hours. The frequency of pulses were to high, this was adjusted but the motor still became too hot after 6 hours of use. I decided to only rotate the plants under personal supervision until a better solution was found.
- Solenoid valve wasn't working for a while. Learned that a separate power supply of 12 volts was necessary to carry out this operation and now this works well with in conjunction with the stepper motor.
- Material mesh was too thick. Plants could not grow outside the mesh. Light didn't seem to get through. Had to find a new nylon material. Even after this, the plants seemed to sprout only inside the mesh and would not puncture through it.



Conclusion

- The rotating plants did not have any significant growth. This was due to the supportive mesh being too thick for plants to pierce through. It may also be due to the lack of light being able to penetrate the soil.

  Also, because the Stepper motor was overheating the plants were not in a full continuous rotation for 1 month as planned. The control plants grew as intended.

  This experiment should be done again with a different type of motor that doesn't overheat so that the plants can be allowed to rotate continuously.

Questions are welcome!

Thank you!

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Acknowledgment:

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