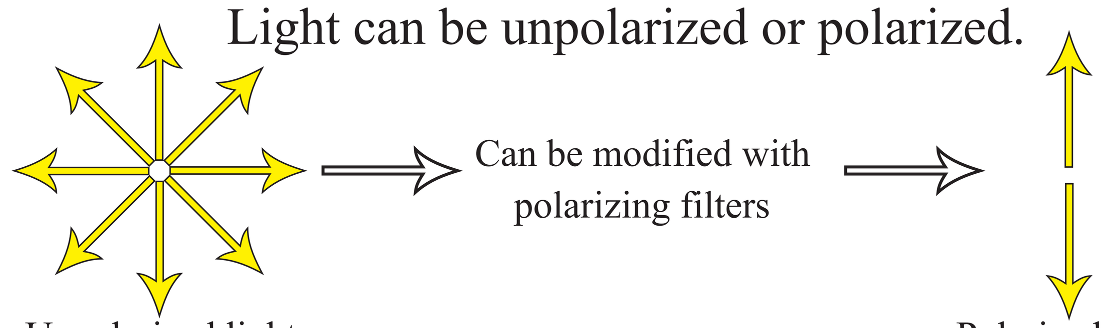
3D Printed Computer-Controlled Rotation Optical Polarizer Mount

Mari Magabo, Dr. David J. Starling, Dr. Joseph Ranalli, Mr. Kenneth Dudeck

PennState Hazleton

Introduction: What is an optical polarizing mount?

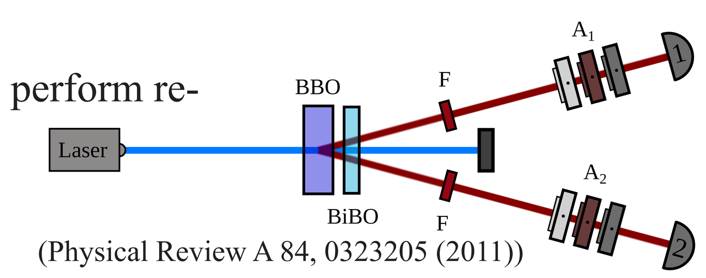
Polarization is a property of light and defined by its electric field component. Light can be unpolarized or polarized.



Unpolarized light
Electric field is oriented randomly.

Polarized light
Electric field is oriented in only one plane.

Many universities (including Penn State Hazleton) perform research involving light polarization.



(Physical Review A 84, 0323205 (2011))

Light polarization is directionally sensitive, and for most experiments, you either need to manually turn a polarizing filter many times in order to collect data (tedious!) OR you can get an automatic mount (convenient!)...

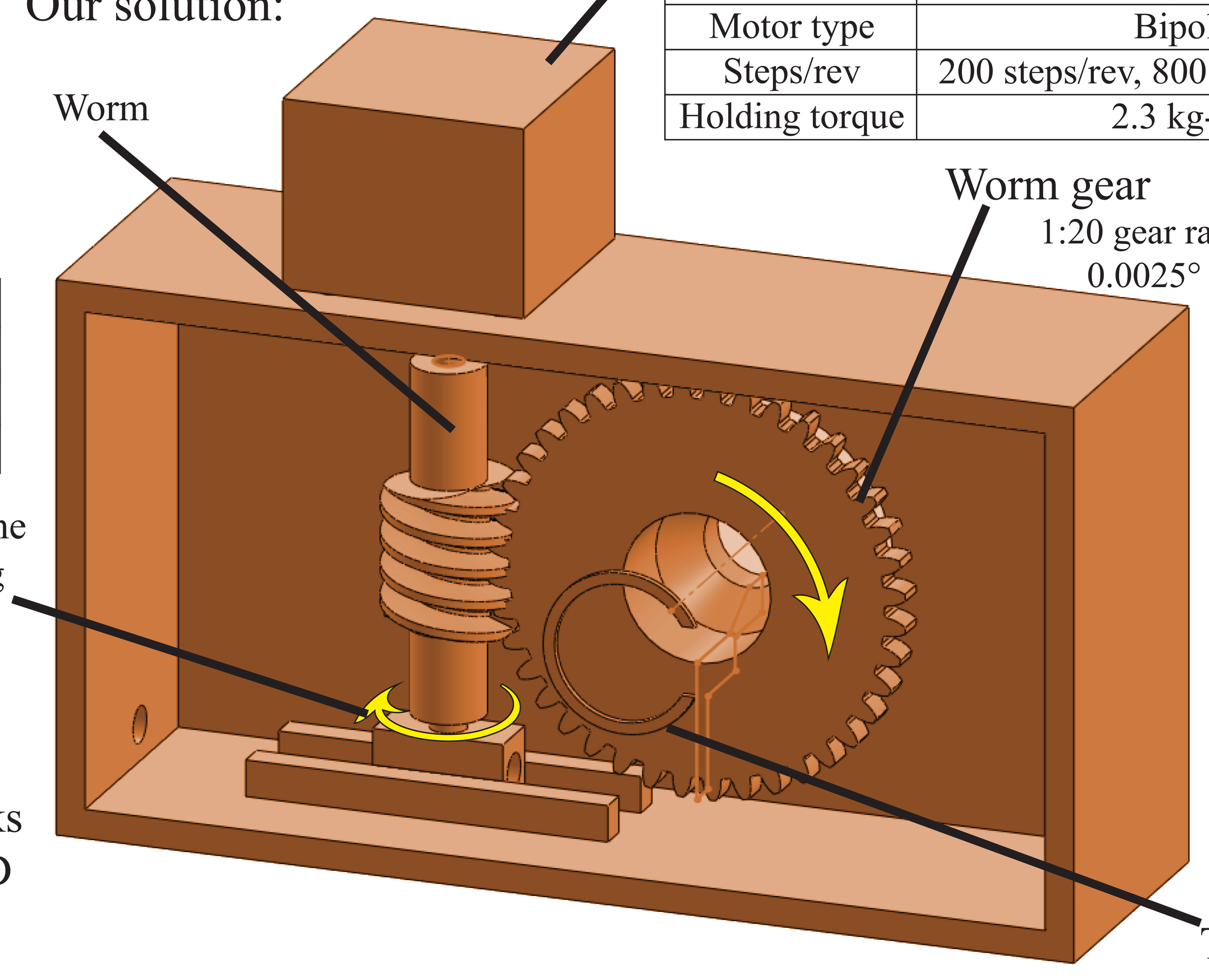
...for about $15,019.

Version 1

Version 1 was based on the Newport PR50PP.

Force Load	10 N
Minimum Angular Motion	0.02°
Angular Range	360° (18,000 steps)
Maximum Speed	20°/s

Our solution:

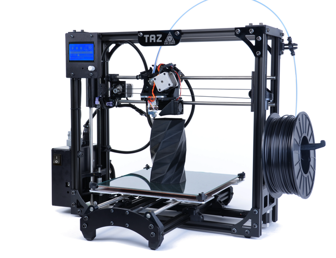


Price	$15
Motor type	Bipolar
Steps/rev	200 steps/rev, 800 microsteps/rev
Holding torque	2.3 kg-cm

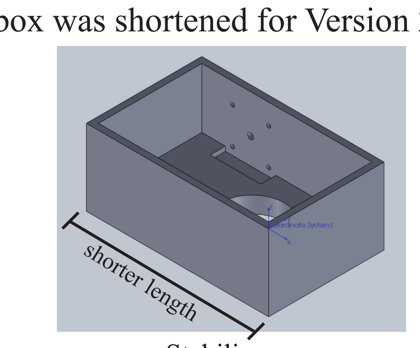
Parts were designed using SolidWorks and printed using a Lulzbot Taz 4 3D printer with PLA filament.

Design Challenges

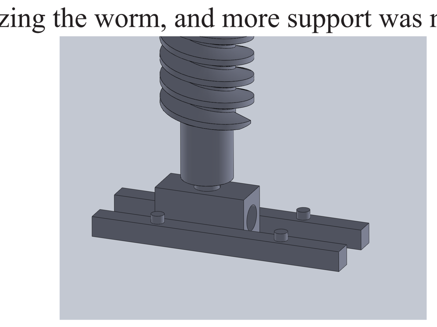
3D printer:
Parts printed smaller than required due to expansion of thermoplastic material.



Containing box:
To save material and printing time, the containing box was shortened for Version 2.

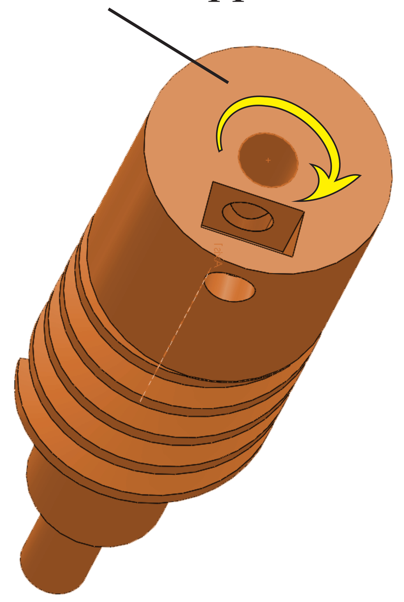


Stabilizers:
Version 1's stabilizers were ineffective in stabilizing the worm, and more support was needed.

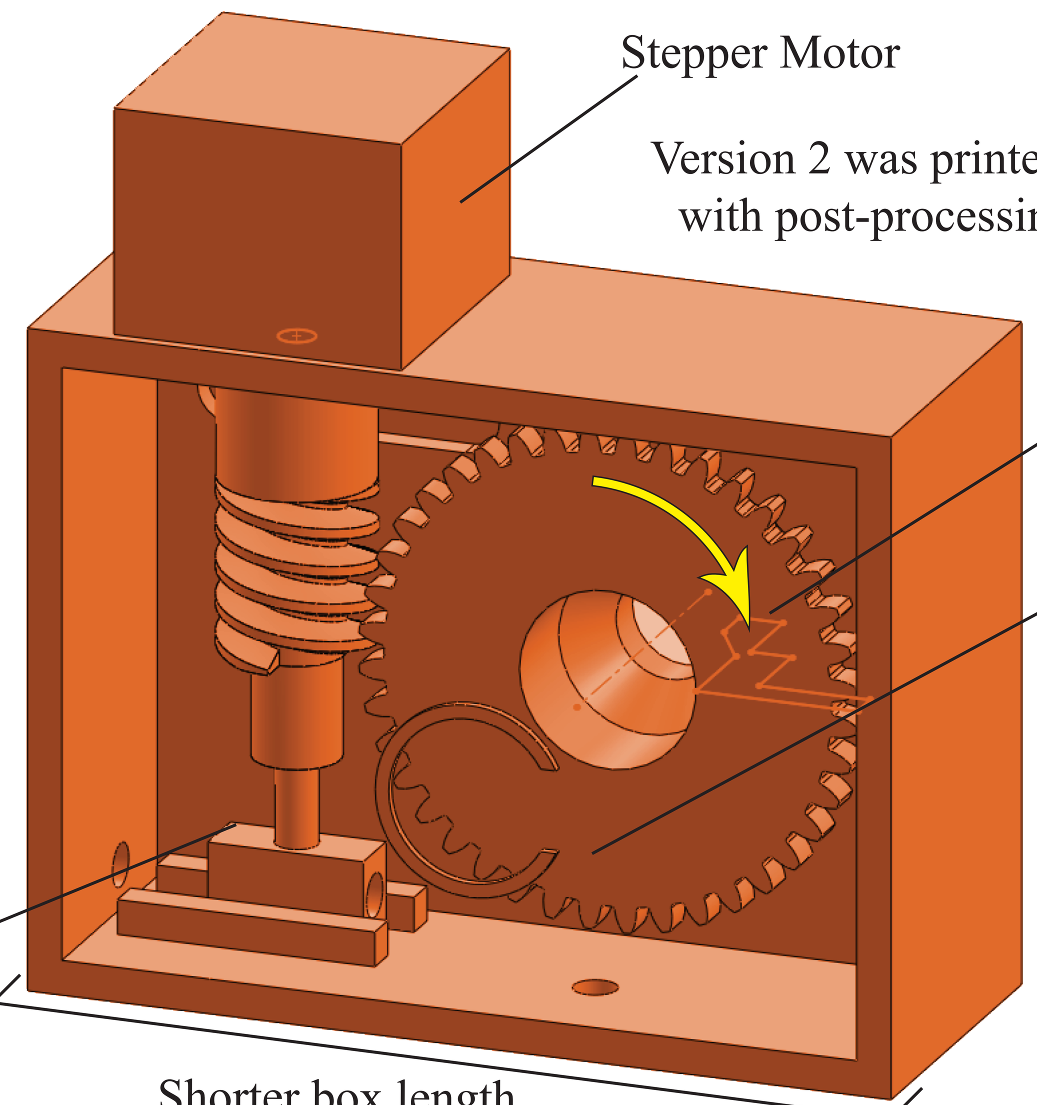


Version 2

New worm with additional supports



Additional stabilization:
We added several holes to accomodate a hex nut and a set screw to hold the worm firmly against the stepper motor shaft.



Version 2 was printed in ABS to help with post-processing of the worm.

More Improvements in the Future

Less material cost:
To save more money, we plan to make the entire set-up more compact.

Acetone Smoothing
To further help with post-processing parts, we plan to use acetone vapor baths to smooth materials.

Source: www.Wired.com

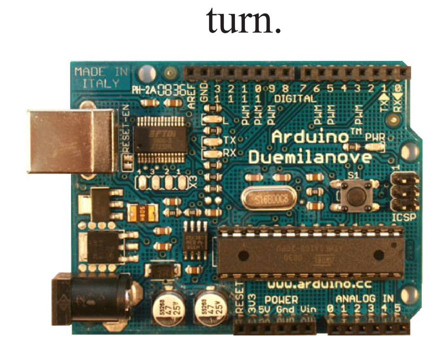
Arduino Control

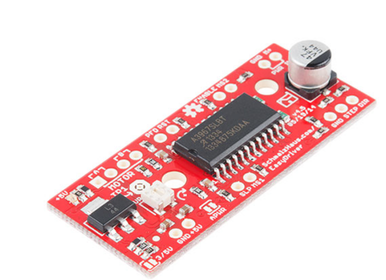
To automatically control the stepper motor, we used an Arduino, an affordable programmable circuit board that can receive inputs and generate outputs according to how we program it.

We needed 16 output signals to control 4 stepper motors, but because Arduinos only have 13 outputs, we used an Easy Driver to reduce the number outputs we need.

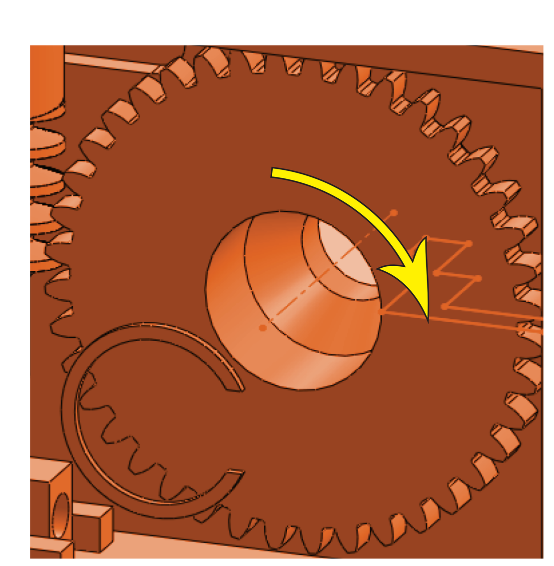
The Process

We tell the Arudino how many times we want the motor to turn.

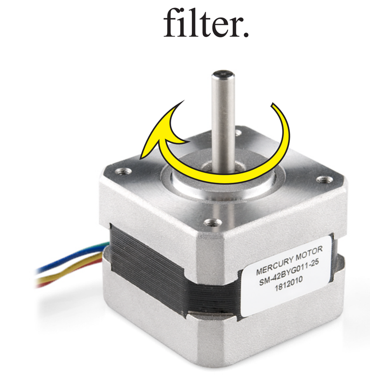




The Easy Driver receives our instructions. It will then drive our stepper motor the way we want.



Stepper motor turns the polarizing filter.



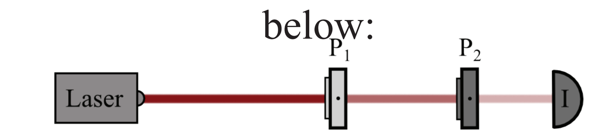
Final Cost Comparison and Conclusion

4 Stepper Motors	$56.00
4 Easy Drivers	$59.80
Arduino Uno	$24.95
3D Printer Material	$9.75
Total	$150.51

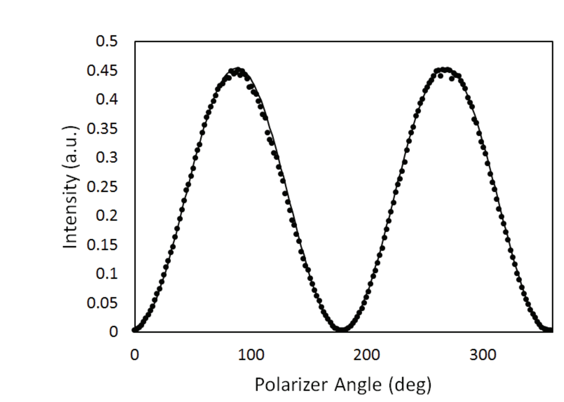
That's only 1% of the cost of a complete high-end lab set-up!

Our stepper motor's minimum angular motion is comparable to the Newport PR50PP, as well, at only 0.0225°. This means we can record data that is just as precise as mounts on the market.

Data collection using setup shown below:



Polarization data matches closely to theoretical results.



The 3D printed optical rotation mount takes viable data and reduces cost dramatically.

This design may provide a low cost solution for research laboratories at smaller universities.

Works Cited

Chilson, Luke. "The Difference Between ABS and PLA for 3D Printing." ProtoParadigm. 23 Jan. 2013. Web. 31 Mar. 2016.

Norton, Robert L. "Chapter 11 - Spur Gears." Machine Design - An Integrated Approach. 2nd ed. 698-99. Print.

Walker, Jearl, David Halliday, and Robert Resnick. "Chapter 33." Fundamentals of Physics. 10th ed. 985-88. Print.