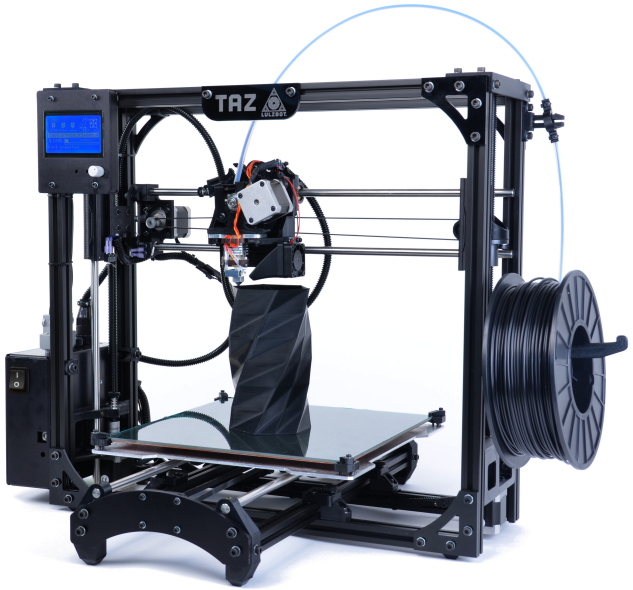
3D Printing Opto-Mechanics



David J. Starling Mari Magabo
Joseph Ranalli Kenneth Dudeck

Penn State Hazleton

January 12, 2015

PENNSTATE
1855

Introduction

Can we replace high-cost computerized optomechanical devices with custom 3D printed parts?

Yes!

- What are opto-mechanics?
- 3D drawings
- Arduino control
- Results

What are opto-mechanics?

Optomechanical parts are mechanical devices used to control optical systems.

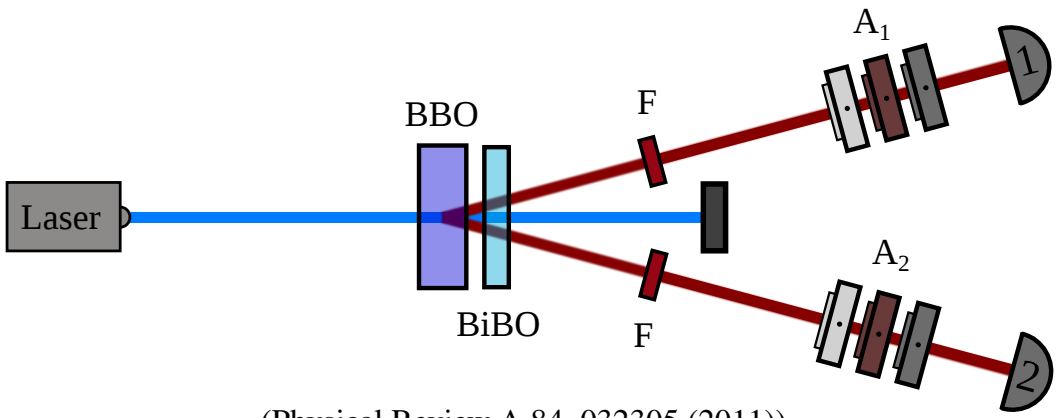
(source: www.thorlabs.com)

Examples:

- Mirror mounts
- Translation stages
- **Rotation mounts**
- Fiber aligners
- Rail and cage mounts
- Pedestals and Posts

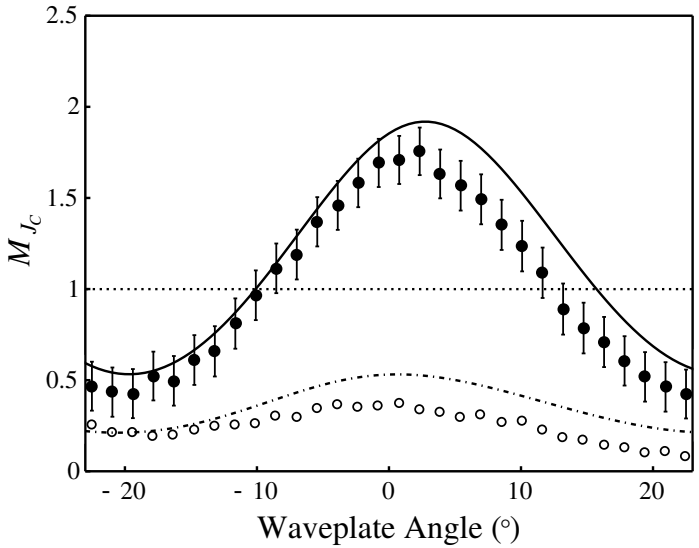
What are opto-mechanics?

Rotation mounts are used primarily with polarizers, quarter- and half-wave plates.



(Physical Review A 84, 032305 (2011))

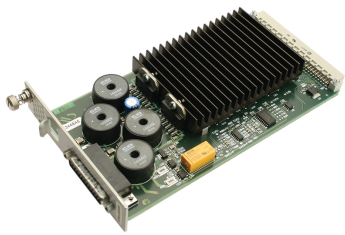
- Polarimetry
- Tests of quantum mech.
- Violate a classical inequality



What are opto-mechanics?

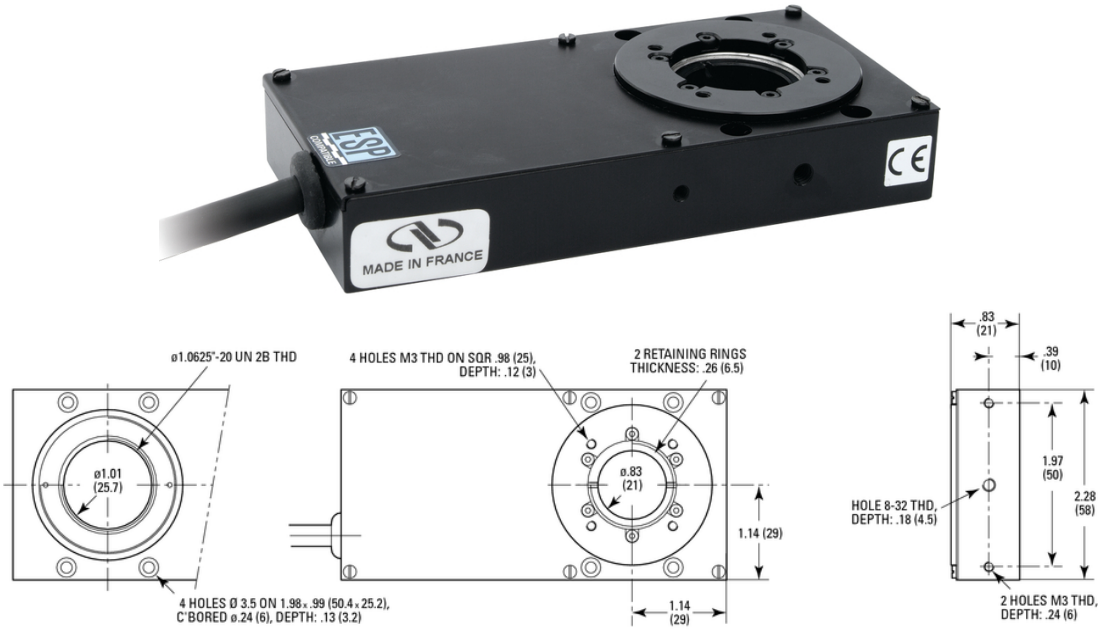
The problem? The cost...

- 4-axis Controller: $6,563
- 4 drive modules: $2,456
- 4 Rotation Stages: $6,000
- Total: $15,019



3D drawings

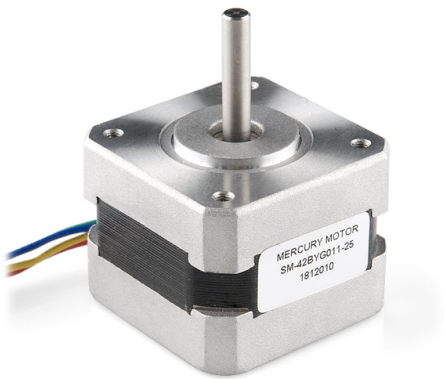
We want to create a comparable device to Newport's PR50PP rotation stage.

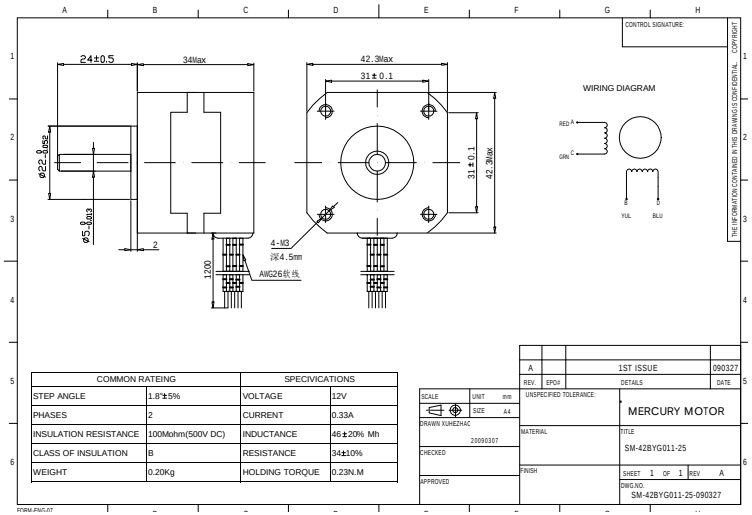


- 10 N load
- Minimum angular motion: 0.02°
- 360° angular range (18,000 steps)
- Maximum speed: 20°/s

3D drawings

We use a low-cost stepper motor for control.





(ROB-09238 at sparkfun.com)

- $15
- Bipolar Motor
- 200 steps/rev, 800 μsteps/rev
- Holding torque: 0.23 N-m

3D drawings

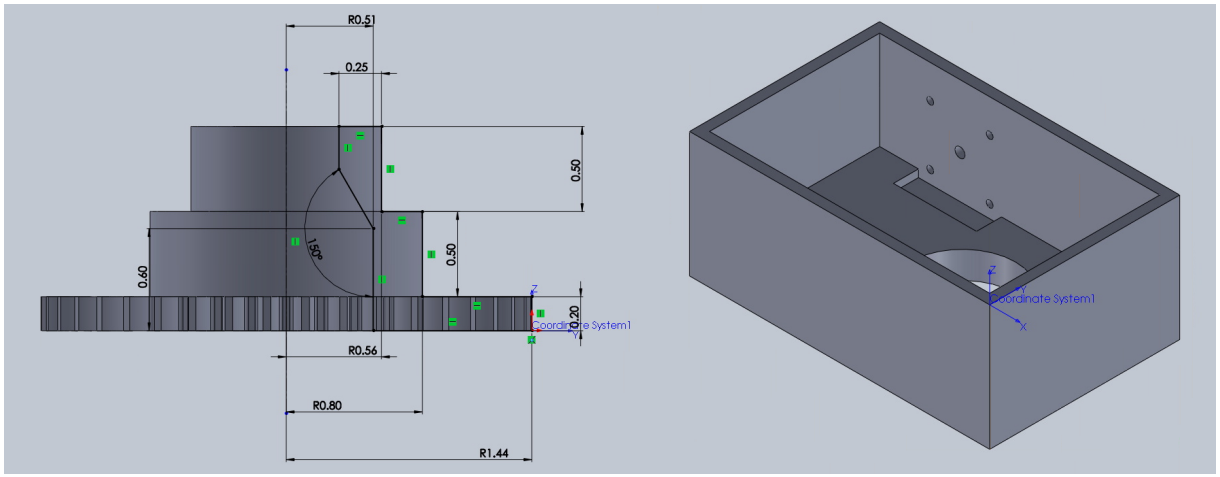
We chose to use a 20:1 ratio worm drive system to couple the stepper to the optic mount.

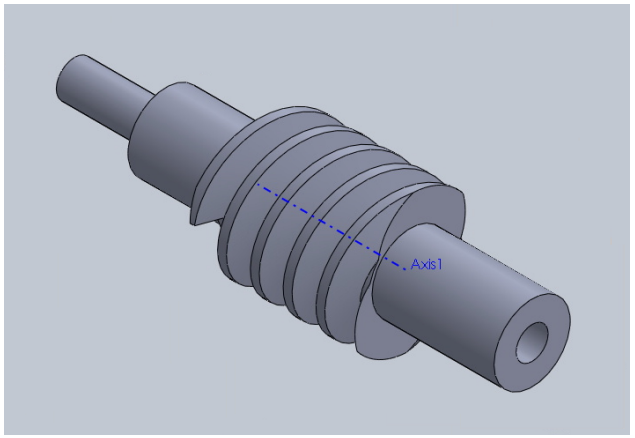
(from wikipedia.org)

This results in 16,000 microsteps per revolution, or 0.023° of resolution.

3D drawings

Each part was drawn in Solid Works, exported to STL, sliced with slic3r and 3D printed using pronterface.

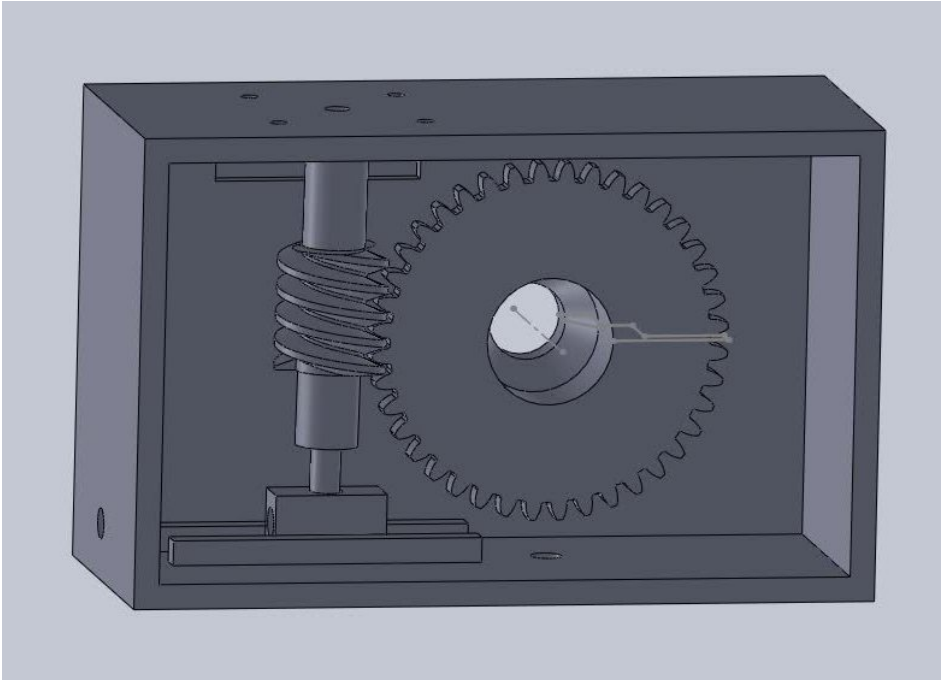




The worm is printed in two parts and glued together.

3D drawings

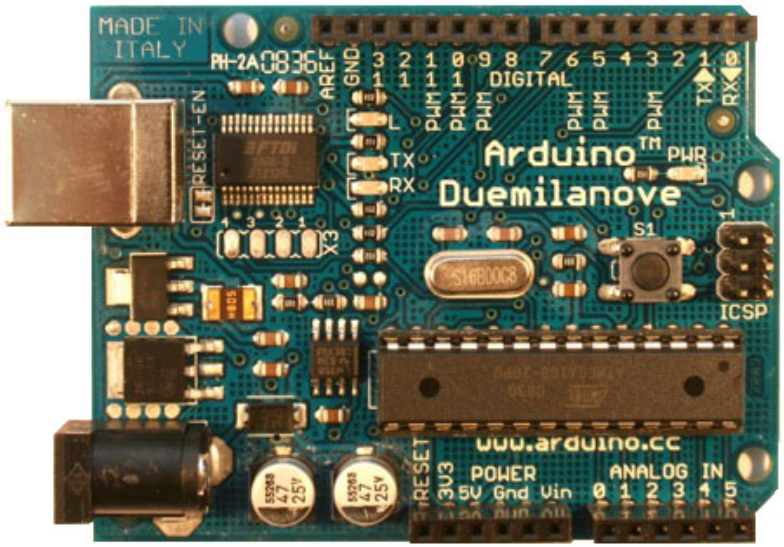
The end product consists of 4 main parts: the optic holder, the main body, the worm and a stabilizing box.

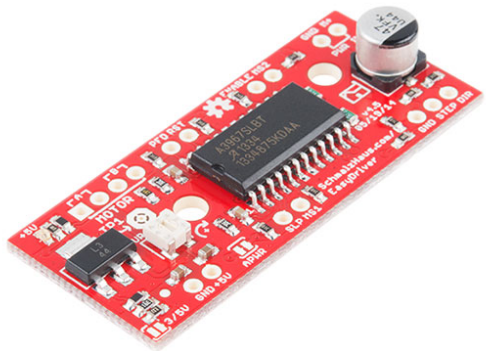


The worm is held against the worm gear with a spring attached to the stabilizing box.

Arduino control

We use an Arduino Duemilanove with an ATmega168 ($11) with an EasyDriver Stepper Motor Driver ($15).

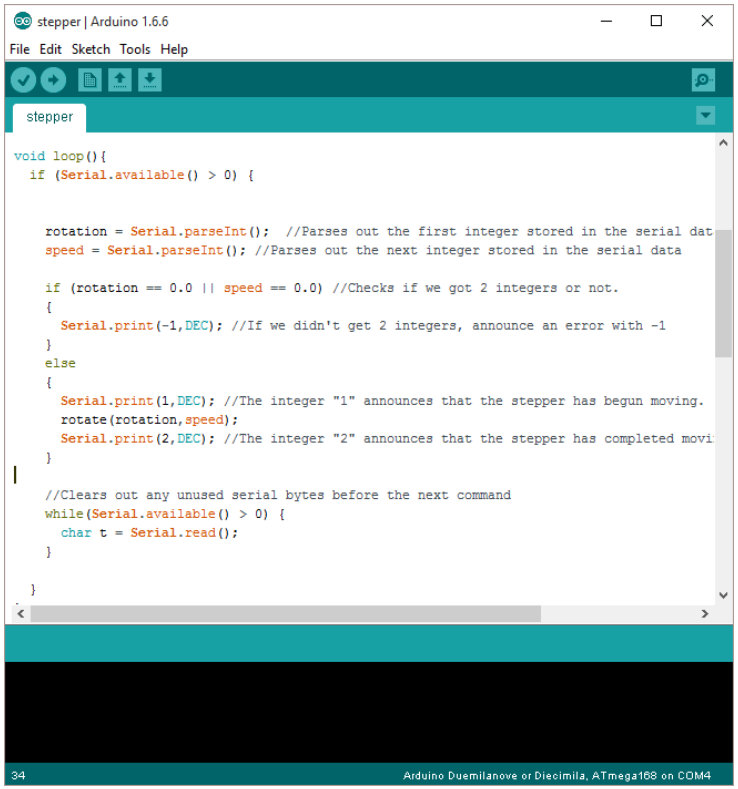




- Cost for arduino, drivers and motors: $131
- Cost for PLA: $19
- Savings: $14,850 or 99%.

Arduino control

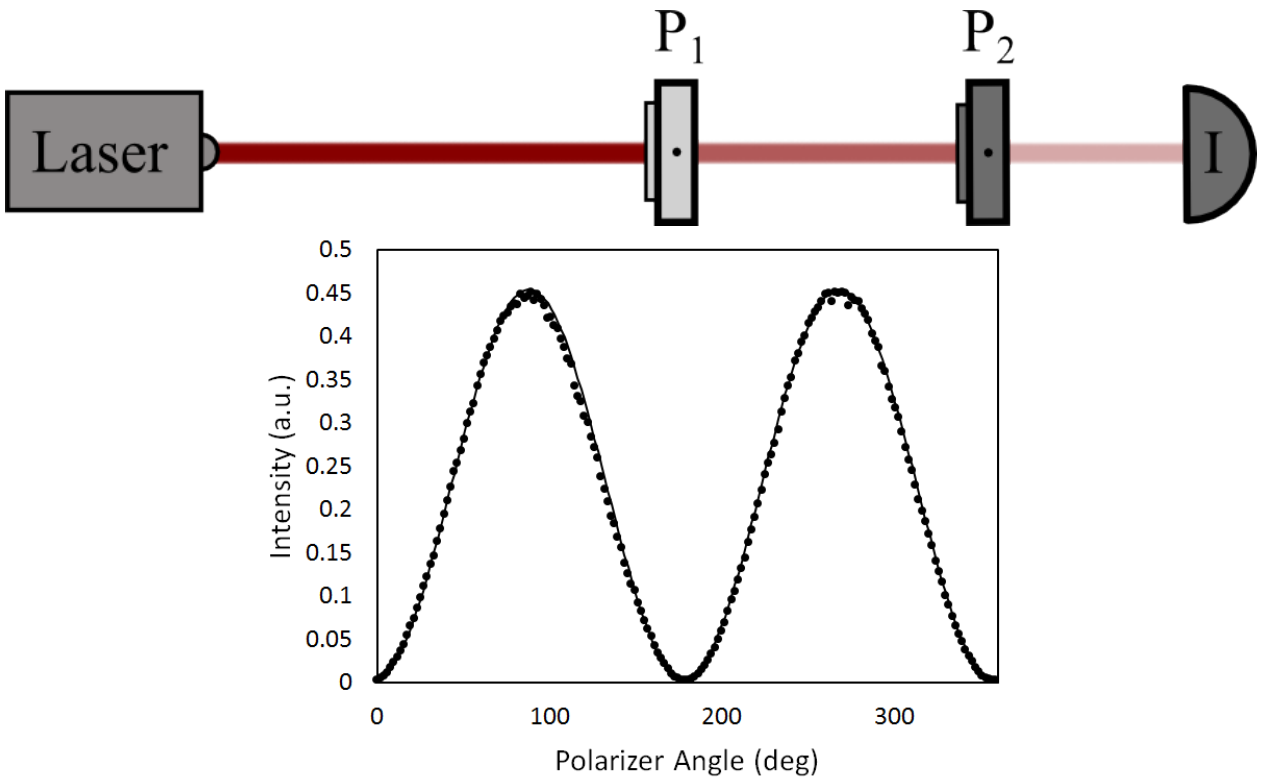
The arduino listens on the USB serial port for commands from the PC.



Commands are sent using python to control the waveplate angle.

Results

We test the rotation control using laser intensity measurements through crossed polarizers.



The data should follow a $I(\theta) = I_0 \cos^2(\theta)$ curve.

Results

We can 3D print and electronically control a rotation mount

(a) good for optics measurements

(b) 99% savings

(c) customizable size, shape, mounting

(d) great undergrad project!

Contact Information:

- David J. Starling
- email: starling@psu.edu
- website: www.david-starling.com