Tues 4/26:

- 1:39 - begin alignment procedure
- Laser height (above rail) = 19.51 +- 0.1 cm
- SA is aligned to laser with retroreflection beside exit aperture
- 1:52 - Spectrum analyzer controller calibrated
    - Rise-time, offset, and amplitude following the instructions
    - Set to:
        - SWEEP EXPANSION: X1
        - AMPLITUDE: 250V
        - OFFSET: MID-RANGE
        - RISE-TIME: FULLY CCW (10 mS)
- 1:55 - Setting two channel oscilloscope:
    - CH 1:
        - Coupling: AC
        - BW Limit: OFF
        - Volts/Div: COARSE
        - Probe: 1X
        - Volts/Div: 1 V (Adjust via control in CH 1 panel)
    - CH 2:
        - Coupling: AC
        - BW Limit: OFF
        - Volts/Div: COARSE
        - Probe: 10X
        - Volts/Div: 50.0 V
- 2:12 - Adjust amplitude to see two peaks in oscilloscope and turn Volts/Div to 20 mV
- 2:38 - Change scope to 1ms/div and adjust amplitude and offset to have two clusters 8 divisions apart (using points that are in phase).
    - 0.125 FSR/div on scope
- 3:01 - Begin A) Polarization
    - Find degree of polarization
- 3:03 - Set up adjustable polaroid linear polarizer 70cm front of laser, with laser 80cm away
    - Wait for mode to change and then take measurements while changing angle of polarizer
- 4:08 - calculate degree of polarization w eq. 4:
    - $\rho = \frac{I_{max} - I_{min}}{I_{max} + I_{min}} = 0.996 \pm 0.04$
    - Need to graph $P(\Theta)\ vs.\ \Theta$
- 4:12 - Begin B) Beam Diameter
- 4:14 - Exercise IV.8:
    - The direction of the beam is the z-axis
    - Write down the equation for the intensity $I(x, y)$ of the beam as a function of the perpendicular distance

- $I(x,y) = \frac{P}{\pi r^2} = \frac{P}{\pi(x^2+y^2)} = \frac{\epsilon_\circ E^2}{2\pi(x^2+y^2)}$
- 4:54 - Exercise IV.9:
  - Measure the beam profile with a power meter, and an adjustable knife edge
  - Mount the laser, power meter, and knife edge on the optical bench
  - For 1st measurement, place knife edge 1-2 cm from laser
  - Measure the total beam power P(x) (arbitrary units will do) as a function of the knife edge position, x

Thurs 4/28:

- 1:30 - set up laser and SA
- Exercise IV.10:
  - $I(x,y) = cI_o \cdot e^{-k(x^2+y^2)}$
  - Where c and k are proportionality factors
  - we know that at $x = y = 0$, the intensity should be at its max, and that the intensity decays exponentially
- Power meter has uncertainty of $\pm\ 1\%$ of total + $\pm\ 5\%$ from detector

Tues 5/3:

- 1:40 - Set up laser and SA
- 1:41 - Exercise IV.1:
    - Using a python model, we got an equation to describe the data
      - beam diameter is the diameter at which the electric field has decayed to 1/e of its maximum value, so that means that the intensity will have decayed to $\frac{1}{e^2}$.
      - Center at $0.003229\ cm$
        $\frac{1}{e^2} \cdot I_{max} = 114.9\ uW$
        Position associated w this is at $-\ 0.015472\ cm$
      - $d_{beam} = 0.055\ cm + 0.015472\ cm = 0.070472\ cm \pm 0.0059\ cm$ (8.3%)

- 2:40 - C) Beam Divergence
  - Wavelength = 632.8nm = 6.328e-4 mm
  - (178.4 +-.1) - (30 +- .4) = $148.4\ \pm 0.25\ cm = l$
  - Trial 1:
    - Max (835) at 1.01 +-0.001
    - 1/e^2 of max (113) at 0.779 +- 0.005
  - $D_0 = d_{beam} = 0.070472 \pm 0.0059 cm$
  - $D_1 = 0.231 \pm 0.019\ cm$ (8.2%)
  - Let $2\Delta\theta = \Theta = divergence$

- From wikipedia: $\Theta = 2arctan(\frac{D_1 - D_0}{l})$
    - From measurements: $\Theta = 1.08 \pm 0.18\, mrad$
- From manufacturer: $\Theta = 1.0\, mrad$
- From Fraunhofer diffraction:
    - $\Theta = 2.44(\frac{\lambda}{D_0}) = 2.19 \pm 0.18\, mrad$

- 4:01 - D) Beam Waist:
    - Lens has $f = 300 \pm 50\, mm$
    - Exercise IV.15:
        - $d = \left(\frac{4\lambda}{\pi}\right)\left(\frac{f}{D_0}\right) = 0.343mm \pm$
        - $L = 2\left(\frac{4\lambda}{\pi}\right)\left(\frac{f}{D_0}\right)^2 = 292.022mm \pm$

Thurs 5/5:

- 1:16 - set up laser
- D) Beam waist continued:
    - Set lens directly in front of laser
    - Place power meter 1 meter away from the lens
    - Take measurements of beam diameter in increments of 5cm, starting 5 cm in front of lens
- 4:42 - Having difficulty getting data that matches our expected result. The beam diameter constantly has a greater value that is not within uncertainty
    - Tried both sides of the lens to see if that would influence the data, but this did not seem to fix the problem
    - The intensity of the laser fluctuated from 760 uW - 815 u W, most likely due to the TEM mode transitions.
    - Beam diameter is affected by the maximum intensity of the laser, as we saw in part B, and finding the beam diameter consecutively over a course of time led to data that varied far too much
        - If the intensity increased while measuring, the beam diameter would increase and skew the data so that the beam waist could not be determined accurately.
        - The same would happen inversely if the intensity increased, but even with this the data collected was much larger than our theoretical value