Benjamin Hogan

2.1 When must you wear Safety Glasses?

- Laser glasses should be put on before one turns on any laser
  (for our uses glasses are optional as the lasers we're using will be difficult to injure us)

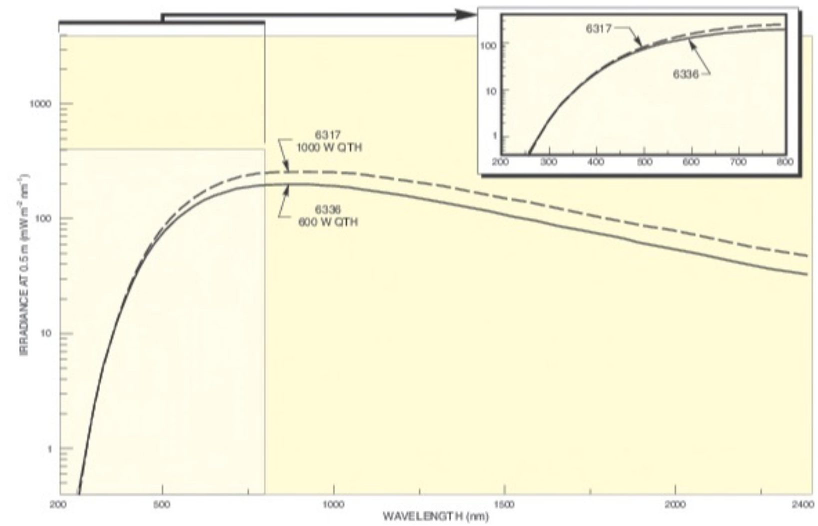
2.2 If a laser glasses are only available in integer-valued optical densities, what laser glasses are required to reduce transmittance by a factor of 200,000?

- An OD rating of 5 will reduce the transmittance by a factor of 100,000 and a OD rating of 6 by 1,000,000.
  Because laser glasses Don't Come in fractional amounts to my Knowledge the laser glasses that are needed is at mininum OD rating 6 or above.

2.3 What are the Saftey habits I'm Supposed to have.

1. laser Glasses
2. Stand upright at all times when working with lasers
3. Take jewelery off
4. Keep the beam horizontal
5. Make sure laser shutter is closed
6. Take break. Don't operate equipment tired
7. Don't look into laser
8. Block the end of beam

2.4 What is the estimated temperature of the figure below?



- The peak wavelength of both spectrums is ~ 800 nm.

From Wein's law $\lambda_{max} = \frac{b}{T}$ $\therefore$ $T = \frac{b}{\lambda_{max}}$ where $b = .0028977\ m \cdot k$

$\therefore$ The temperature is roughly,

$$T = \frac{(0.0028977\ m \cdot k)}{(800 \cdot 10^{-9} m)} = 3{,}622\ K$$

Wein's law is useful when you have wavelenght vs. insensity plots

2.5 Why is the filament bright in the middle but dim on the ends?

(Assume constant cross-sectional area)

* Artistic Representation

My guess is that the center of the filament has the peak electrical current while the ends have less. This beacse more electrons are being released from the middle than the ends due to the photoelectric effect.

2.6 Explain why a thermopile can accurately measure the total power in a beam of broad-band light with an unknown spectral distribution, but a photodiode cannot?

- The advantage of a termopile is that it can measure power output of light without the need of a spectrum distribution. This because it is a sensor that detects changes in temperature from incoming light. The energy of the beam creates heat which can be used to calculate power without the use of a spectrum.

2.7 Calculate the # of photons per second leaving the aperture of a laser.

ⓐ

Given:	Find:	Formula:	Calculations:
$P_{laser} = 1\,mW$	$N = \frac{Photons}{sec}$	$E = \frac{hc}{\lambda}$	$E = \frac{hc}{(632.8 \cdot 10^{-9} m)} = 3.139 \cdot 10^{-9} J$
$\lambda = 632.8nm$		$N = \frac{P_{laser}}{E}$	$N = \frac{(1 \cdot 10^{-3} W)}{(3.139 \cdot 10^{-9} J)} = 3.186 \cdot 10^{15}$ Photons/sec

The amount of photons leaving the aperture per second is $3.186 \cdot 10^{15} \frac{Photons}{sec}$.

ⓑ What is the average Power if only one photon left per second

Given	Find:	Formula:	Calculations:
$\lambda = 632.8nm$	$P_{avg} = ?$	$P = N \cdot E$	$P_{avg} = (1 \frac{Photon}{sec})(3.139 \cdot 10^{-9} J) = 3.139 \cdot 10^{-19} W$
$N = 1 \frac{Photon}{sec}$		$E = \frac{hc}{\lambda}$	

If only a single photon left the aperture the average power would be $3.139 \cdot 10^{-19}$ W.

2.8 Find an expression for the relative uncertainty $\frac{\Delta f}{f}$ in the focal length f in terms of a, Δa, b, and Δb, when f is given by $\frac{1}{f} = \frac{1}{a} + \frac{1}{b}$.

$$\frac{1}{f} = \frac{1}{a} + \frac{1}{b} \Rightarrow f = \frac{ab}{b+a}$$

$$\frac{\Delta f}{f} = \sqrt{\left(\frac{\partial f}{\partial a}\frac{\Delta a}{a}\right)^2 + \left(\frac{\partial f}{\partial b}\frac{\Delta b}{b}\right)^2}$$

$$\frac{\partial f}{\partial a} = \frac{b^2}{(b+a)^2}$$

$$\frac{\partial f}{\partial b} = \frac{a^2}{(b+a)^2}$$

$$\frac{\Delta f}{f} = \sqrt{\left(\frac{b^2}{(b+a)^2}\frac{\Delta a}{a}\right)^2 + \left(\frac{a^2}{(b+a)^2}\frac{\Delta b}{b}\right)^2}$$

2.9 Show that $f = N^{ka}$, where N, k are constants, then $\frac{\Delta f}{f} = |k\ln(N)|\,\Delta a$

$$N^{ka} = e^{ka\ln(N)} \quad \text{by exponent rules}$$

$$\therefore f = e^{ka\ln(N)}$$

$$\Delta f^2 = \left(\frac{\partial f}{\partial a}\Delta a\right)^2 \Rightarrow \left(\frac{\partial}{\partial a}e^{ka\ln(N)} \cdot \Delta a\right)^2 = \left(|K\ln(N)|e^{ka\ln(N)}\Delta a\right)^2$$

$$\frac{\Delta f^2}{f^2} = \frac{\left(|K\ln(N)|\,e^{ka\ln(N)}\right)^2}{\left(e^{ka\ln(N)}\right)^2}\Delta a^2 = |K\ln(N)|\,\Delta a^2$$

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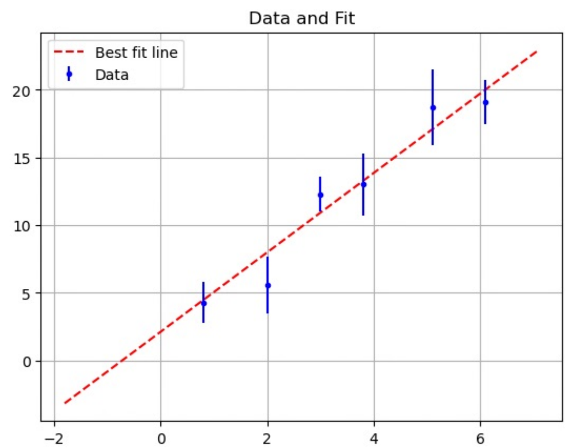
2.12 Fit the data : $y = ax + b$. What is a, b? Is the func. Consitent with the data? By plotting the χ^2 cut through the minimum parallel to a axis. find uncertainty in slope.

I used python Code :

The fit Data:



$$y = a_1 + a_2 X$$

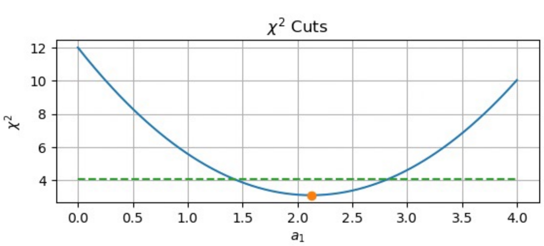
$$a_1 = 2.124$$

$$a_2 = 2.932$$

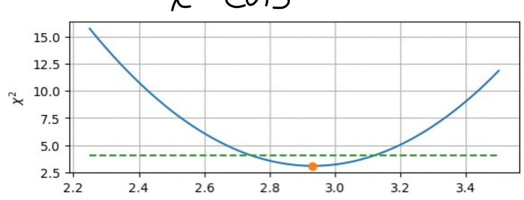
I then found $\chi^2_{reduced} = 0.78$

This means the fit is quite close to our data and thus is consistent with it. I then found the uncertainty in the parameters.

This was found Via χ^2 cuts



χ^2 cuts



$$\Delta a_1 = \pm 1.43$$

$$\Delta a_2 = \pm 0.39$$

* Python Code was adapted from Dr. Greterson's Github.