1. (8 pts) The Nd:YAG laser has a wavelength of 1064 nm and a linewidth of 5 cm\(^{-1}\).
   a) What is the center frequency of the 1064 nm laser transition?
   
   b) What is the photon energy in eV?
   
   c) What is the linewidth in frequency?

2. (6 pts) A Si PIN photodetector is used to detect a 1 mW beam of 780 nm laser radiation. At 780 nm the quantum efficiency for this AR-coated Si detector is 80%. If the Si detector is used in the circuit below, what is the expected signal, \( V_{\text{out}} \)? Assume a reverse leakage current of 1 nA for the PIN detector.
3. (4 pts) A pulsed laser beam with “square” pulses of 1 $\mu$s duration and a pulse rate of 1 kHz has an average power of 10 W.
   a) What is the peak power per pulse?
   
   b) What is the energy delivered per pulse?

4. (10 pts) An unknown laser is emitting from a “black box” in a TEM$_{oo}$ mode into a scanning Fabry-Perot interferometer as shown below. The scanning output from the detector is also shown on the oscilloscope trace.

   a) What is the wavelength of the laser?

   b) How long is the laser cavity inside the “black box”?

   c) If the scanning FPI is changed to 3 cm spacing, sketch the new oscilloscope output.
4. (14 pts) You are required to design an optical resonator for the new “Beaver” laser with a wavelength of 600 nm (ORANGE color!). The cavity length is to be 1 meter and will use one flat and one curved mirror. The minimum beam radius (spot size) is to be 400 µm.

a) Specify the required radius of curvature for the output mirror.

b) What are the radii of curvatures of the beam at both mirrors?

c) What will be the beam diameter 100 m beyond the output mirror?

d) If the diameter in c) is too large, how would we need to change the beam design to get a smaller spot size at 100 m?

e) If the flat mirror is 100% reflecting and the gain-medium length is 50 cm, what is the range of reflectances for the output mirror for the laser to be above threshold? How would the laser output power behave over this range of outputs (qualitative only)?