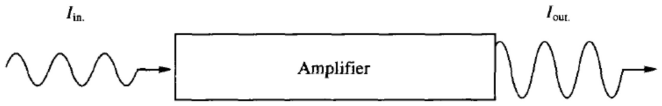
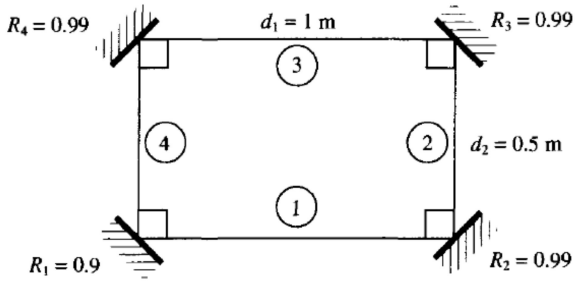
Indian Institute of Technology Guwahati
Department of Physics
PH306/Lasers & Ultrafast Optics/2022-23/Tutorial-2/AKSharma
Due date: 23.02.23

1. An experiment involving a homogeneously broadened optical amplifier is depicted in the diagram below. For an input intensity of 1 Wcm^{-2}, the gain (output/input) is 10 dB. If the input intensity is doubled to 2 Wcm^{-2}, the gain is reduced to 9 dB.
   (a) What is the small signal gain of this amplifier?
   (b) What is the saturation intensity?



2. A laser system consists of an active medium in the form of a rod of length 0.12 m and diameter 0.5 mm. It has a gain of 60 m^{-1}. One end of the rod is coated with 100% reflective layer. Can the laser reach saturation intensity?
3. A hypothetical laser rod of length 0.15 m and diameter 5 mm is coated with a 100% reflector at one end of the rod and no reflector at the other end (it has an antireflection coating on that end). It operates at a wavelength of 800 nm and is homogeneously broadened. The upper laser level has a lifetime of 200 μs. The pumping flux is such that the laser is at threshold, and the population difference between the upper and lower laser level for that condition is measured to be 1×10^{26} m^{-3} . What is the intensity of the laser at the output end of the rod?
4. Refer to the optical cavity shown in the diagram below



   (a) If the optical paths 1 through 4 are lossless, what is the photon lifetime of this cavity?
   (b) What is the cavity Q (assume that the wavelength region of interest is 5000 Å)?
   (c) Suppose that path 1 has a transmission coefficient of 0.85 rather than 1 as in (a). What is the new photon lifetime?
   (d) Suppose that path 1 had a power gain of 1.1. What is the new photon lifetime?

(e) If we blindly plug into the formulas, τ_p becomes negative for G sufficiently large. What is the meaning of this apparent absurdity?

5. A pulsed Nd:YAG laser rod of length 0.1 m and diameter 8 mm is flashlamp pumped and is measured to have a single-pass gain (I/I_0) of 5 at the laser wavelength of 1.06 μm. The pumping duration and the output pulse is 230 μs, so we may think of it as a quasi-continuous beam. The rod also has measured scattering losses per pass of 0.5%. Mirrors are installed at each end of the rod. What would be the optimum transmission for the output mirror if a high reflecting mirror is used at one end of the cavity and the output mirror at the other end? What would be the output power with this mirror combination? Assume that the laser beam diameter is the same as that of the laser rod. Take stimulated emission cross-section as 2.8×10^{-23} m^{-2}.