NAVAL POSTGRADUATE SCHOOL
Monterey, California

EC 3210 FINAL EXAM 12/97 Prof. Powers

- This exam is open book and notes.
- There are five problems; each is equally weighted.
- Partial credit will be given; be sure to do some work on each problem.
- Be sure to include units in your answers.
- Please circle or underline your answers.
- Do *NOT* do any work on this sheet.
- Show *ALL* work.
- Enter your name in the space provided.
- Exams and course grades *should* be available outside the Optical Electronics Laboratory (Bu 224) on **Friday afternoon, 19 December**.
- Have a good holiday season and enjoy your break!

Course grade: ______________

1		4	
2		5	
3			
TOTAL			

Name: ____

1. A Gaussian beam from a laser operating at 1300 nm has a spot size of 2.2 mm and a radius of phase curvature of 10.9 m. Find the value of the waist *and* the location of the waist relative to the plane where the spot size and radius of curvature are given.

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2. A laser operates with paramters given in the table below. Find the value of the optimum mirror reflectivity for the right (output) mirror.

Parameter	Value
Left mirror power reflectivity	100%
Mirror separation	15 cm
Volume of lasing medium	1 cm^3
Refractive index of lasing medium	1.40
Lasing wavelength	1.06 μm
Lineshape	Lorentzian
Linewidth	1 GHz
Unsaturated population inversion	$1{\times}10^{11}$ atoms
B_{ij}	4×10^{18} $s^{-2}{\cdot}j^{-1}{\cdot}m^3$

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3. A mode-locked laser produces a train of triangular pulses with a pulse repetition frequency of 1×10^9 pulses per second. The pulsewidth (FWHM) of each pulse is 1 ps. The index of refraction of the lasing medium is 1.5.

   (a) Find the number of modes that are locked together.

   (b) Prove that $P_{\text{peak}} = NP_{\text{average}}$ where P_{peak} is the peak pulse power, N is the number of modes, and P_{average} is the average power of the pulse train.

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4. A lasing material, npsium, has the energy levels in Figure 1. It is a three-level laser that uses levels 0, 1, and 2. Transitions to energy levels A, B, C, and D are nonradiative. The material is lifetime broadened. The transition lifetimes are given in the table below.

Lifetime	Value	Lifetime	Value
τ_{20}	1 ms	τ_{10}	10 ns
τ_{21}	1 ns	τ_{1C}	10 ms
τ_{2A}	0.1 ms	τ_{1D}	50 ms
τ_{2B}	0.1 ms		
τ_{2C}	1 μs		
τ_{2D}	10 ns		

We want to design a scanning Fabry-Perot interferometer to measure the frequency lineshape, $g(\nu)$.

   (a) Calculate the required spacing of the scanning interferometer mirrors, d, to ensure unambiguous measurement of $g(\nu)$.

   (b) For the spacing calculated in part (a), find the FWHM of the resonator's response if each mirror power reflectivity is 99%.

Figure 1: Energy levels and lifetimes for Problem 4.

5. A vertically polarized ligth wave passes through a linear polarizer (LP1), a polarizing prism made of lithium niobate (with an air gap between the sections), and a second linear polarizer (LP2), as shown in Figure 2. The polarization axis of LP_1 is rotated $-60°$from the vertical (as seen by the approaching lightwave); the axis of LP_2 is at an angle of $+30°$.

   (a) Calculate the range of possible prism angles, ϕ, for the polarizing prism.

   (b) Calculate the output power from the assembly is the input power is 5 mW.

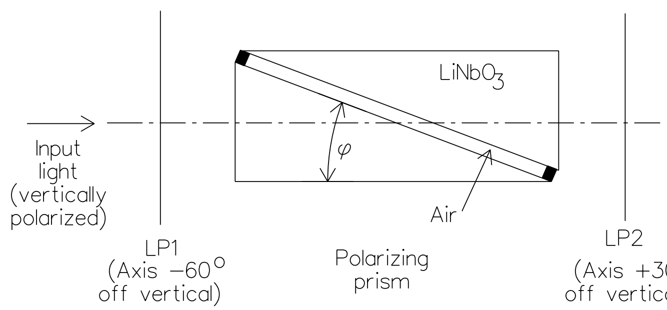

Figure 2: Arrangement of components for Problem 5 (side view).