PHY 431 Homework Set #10

Total 105% + 0.5 Bonus Credit

Due December 6 at the start of class

1) Pedrotti Problems 19-11, 19-12, 19-13, 19-14,19-15 [30%]
2) ***Human Eyes [15%]***
   Estimate the size of sensitive cells of the human eye, provided that the entrance pupil of the eye about 1 mm in diameter under usual sunlight conditions. Assuming the size of sensitive cells is such that diffraction limit is met.

2) ***Irradiance/Human Eyes*** (30%)
   (A) (5%) Estimate the average number of photons per second per square centimeter reaching Earth's surface from the sun. At the earth's surface, the suns irradiance is approximately 300 W/m^2.
   (B) (5%) A green laser pointer puts out 1 mW at a wavelength of 532 nm. How many photons are emitted per second?
   (C) (5%) Supposed you are seated 10 m from a screen onto which a speaker shines his laser pointer. Assume that the screen scatters 20% of the radiation incident upon it, and that you eye's pupil has a diameter of 5 mm. What is the rate at which photons from the laser pointer enter your eye?
   (D) (15%) Compare the **irradiances** at the retina that result when looking:
      (a) Directly into the sun. The sun subtends an angle of 0.5 degrees. Assume that the pupil of the bright-adapted eye is 2 mm in diameter with focal length of 22.5mm.
      (b) Into a 1 mW green laser pointer (wavelength=532 nm). Assume the beam waist of the laser is 1 mm, and the laser is located 1m from the eye.
      (c) Which one will damage your eye? Eye-damaging intensities are in the range of 10mW/cm^2.

3) Fourier Optics [15%]
   (a) Let a plane monochromatic wave fall on an aperture which is placed on the first (front) focal plane of a positive thin spherical lens. Represent the angle of diffraction in terms of spatial frequencies over the second (back) focal plane of the lens.
   (b) Let a plane monochromatic wave fall on a transmission diffraction grating, which has an amplitude transparency function $t(x) = 1 + a\cos(\Omega_0 x)$, with $a < 1$. Find the intensity distribution on a plane parallel to the grating at a distance Δz.

4) Optical Apodization [15%]
   Optical apodization is the process by which the aperture function of the system is altered to redistribute the energy in the diffraction pattern. To improve the resolution, consider the example where the transmission is modified by a cosine function, cos ($\pi x/b$), between –*b/2*and +*b/2*, where *b* is the slit width. Calculate the position of the n-th minimum of the single-slit Fraunhofer diffraction pattern, and compare it with the position of the n-th minimum of the unapodized slit of the same width b.

Gaussian Beam and Lens (Bonus +0.5 point)

The laser resonator shown in the figure below with z = 0 located at the flat mirror and its output impinges on a lens of focal length 10cm. Assume the beam waist size, w_0=0.5mm; laser wavelength, λ = 632.8nm; and distance of the lens to laser output mirror, d=50 cm.

A. What is the far-field beam divergence in mrad?
B. What are the spot size and radius of the curvature of the output laser beam on the lens?
C. What is the radius of the curvature after passing through the lens?
D. What is the spot size at the focal point after the lens if the clear aperture of the lens is 1.5cm in radius?
E. What is the beam radius if the laser beam is propagated 1m further after the focal point? And what is the far-field beam divergence with the lens?

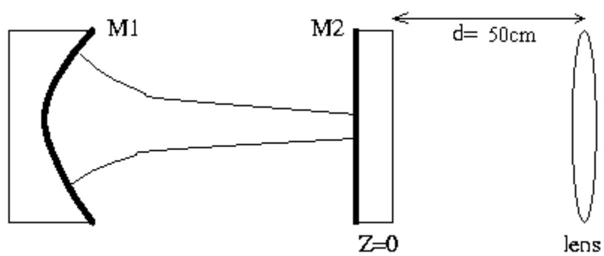

Figure 1