EE 119 Homework 11

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1. ***General diffraction questions***
   (a) How many wavelengths wide must a single slit be if the first Fraunhofer diffraction minimum occurs at an angular distance of 30 degrees from the optic axis?
   (b) Lycopodium seeds, which are of spherical shape and nearly uniform size, are dusted on a glass plate. If with parallel light of 640nm wavelength the angular radius of the first diffraction maximum is 2 degrees, estimate the size of the seed.
   (c) If the headlights of an approaching car are 122cm apart, what is the maximum distance at which the eye can resolve them? Assume the pupils of 4mm in diameter and light of 500nm wavelength. Consider diffraction limit only.

2. ***Diffraction grating.*** A molecule sometimes emits light at 600nm and sometimes emits light at 650nm. You want to determine the relative intensity of emission at these two wavelengths, so you decide to split the light with a diffraction grating and direct the two first-order diffracted beams of different colored light onto two different photodetectors which are placed 10cm away from the grating. You want to separate the centers of the photodiodes by 2cm. The active area of the photodiode is 0.5mm × 0.5mm, and to maximize efficiency you want all of the light at the two wavelengths to hit the active area. Please design the first-order diffraction grating you will use.

3. ***Interference*** Sketch the interference pattern produced in the x-y plane by two plane waves, where for wave 1, the wavevector is $\mathbf{k}_1 = (2\pi/\lambda)(\mathbf{x} + \mathbf{y} + \mathbf{z})$, and for wave 2, the wavevector is $\mathbf{k}_2 = (2\pi/\lambda)\mathbf{z}$. Take $\lambda = 500$ nm. Quantitatively label the dimensions on your sketch.

4. ***Young's double slit Experiment.*** Young's double slit experiment is described in Fig.1. Answer following questions.
   (a) Plot the intensity pattern at the observing plane, P_o. Label x and y-axis clearly.
   (b) Light passes through two slits separated by a distance d=0.8mm, and the observing plane is 1.6m away from the two slits. If the distance between the two consecutive maxima is 5mm, what is the wavelength of the light?
   (c) When one of the slits is covered by a film of transparent material, the zeroth order is seen to shift by 2.2 fringes. If the refractive index of the transparent material is 1.4, how thick is the film?
   (d) The two slits are illuminated by light containing two wavelengths, 450nm and 600nm. What is the least order at which a maximum of one wavelength will fall exactly on a minimum of the other?

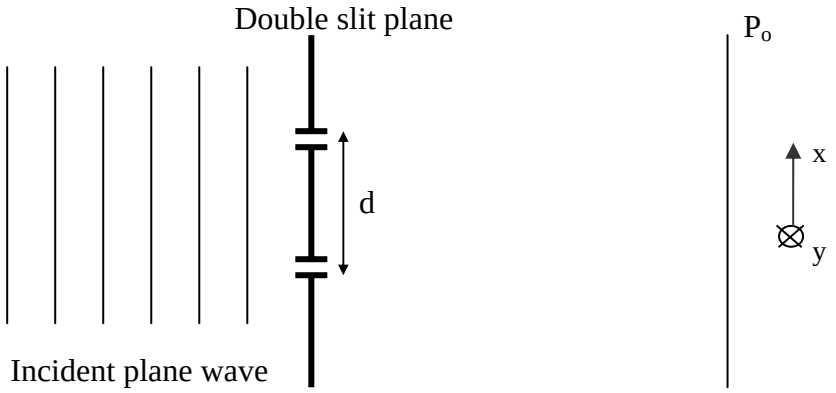

Fig.1

5. ***Michelson Interferometer***
   (a) How far must the movable mirror of a Michelson interferometer be displaced for 2500 fringes of the red cadmium line (6438 Å) to cross the center of the field of view?
   (b) If the mirror of a Michelson interferometer is moved 1.0 mm, how many fringes of the blue cadmium line (4799.92 Å) will be counted crossing the field of view?

6. ***Sagnac interferometer*.** A HeNe laser is used in a Sagnac interferometer. What area would be necessary so that a rotational velocity of 3 rad/s would correspond to 1 fringe shift?

7. ***Newton Rings*.** In an experiment involving Newton's rings, the diameters of the fifth and fifteenth bright rings formed by sodium yellow light (5889.95Å) are measured to be 2.303 and 4.134 mm, respectively. Calculate the radius of curvature of the convex glass surface.

8. ***Anti-Reflective Coating***
   (a) Design an anti-reflective coating for light of wavelength 950 nm to place on top of GaAs (n=3.6).
   (b) Explain your design process. Specifically, what are the criteria which must be met to ensure zero reflected intensity?